Focus on Energy
2016 Energy Efficiency
Potential Study

June 30, 2017

Public Service Commission of Wisconsin
610 North Whitney Way
P.O. Box 7854
Madison, WI 53707-7854

The Cadmus Group, Inc.

An Employee-Owned Company • www.cadmusgroup.com

This page left blank.

Prepared by:
Lakin Garth
Aquila Velonis
Taylor Bettine
Andrew Grant
Ann Sojka
Kari Heinrich
Jane Colby
Jim Stewart
Steve Cofer
Charlie Bicknell

Cadmus
Seventhwave
St. Norbert's Research Institute
Martec Group

This page left blank.

Table of Contents

Appendices

List of Tables

List of Figures

List of Acronyms

ACEEE: American Council for an Energy-Efficient Economy

B/C: Benefit-cost

BAU: Business-as-usual

CBECS: Commercial Building Energy Consumption Survey (Energy Information Agency)

DOE: U.S. Department of Energy

ECM: Electronically commutated motor

EERE: U.S. Department of Energy Office of Energy Efficiency and Renewable Energy

EIA: U.S. Energy Information Agency

EISA: Energy Independence and Security Act of 2007

EUL: Effective useful life

EUI: End-use Intensities

GWh: Gigawatt hours

ISPP: Industrial Savings Potential Project

kWh: Kilowatt hour

MECS: Manufacturing Energy Consumption Survey (Energy Information Agency)

MTRC: Modified total resource cost

MW: Megawatt

MWh: Megawatt hour

NPV: Net present value

NREL: National Renewable Energy Laboratory

O&M: Operations and maintenance

PSC: Public Service Commission of Wisconsin

PTAC: Package Terminal Air Conditioner

RECS: Residential Energy Consumption Survey (Energy Information Agency)

SCT: Society cost test

SPECTRUM: Statewide Program for Energy Customer Tracking, Resource Utilization and Data Management

TAC: Technical advisory committee

TRC: Total resource cost

TRM: Technical reference manual

UCT: Utility Cost Test

VAV: Variable air volume

VFD: Variable frequency drive

VSD: Variable speed drive

Executive Summary

Study Objectives

The Public Service Commission of Wisconsin (PSC) contracted with Cadmus to complete an energy efficiency potential assessment, designed to produce estimates of the conservation resources achievable by Focus on Energy over a 12-year period, from 2019 through 2030. The study's objectives included the following:

- Inform future program planning by assessing future energy savings potential for measures offered through existing Focus on Energy programs and by identifying additional measures with high savings potential
- Estimate the achievable energy savings potential for various scenarios, including a business-as-usual (BAU) scenario, which assumes Focus on Energy funding of approximately $100 million per year (defined by current statute), and alternate scenarios that assume no funding limits and illustrate the effects of changes in program policies and assumed market conditions.

Scope of Analysis

This study analyzed six sectors:

SINGLE-FAMILY	Single-family and manufactured homes.
MULTIFAMILY	Multifamily apartment buildings and homes (4 or more units).
COMMERCIAL	Commercial offices, grocery, healthcare (hospitals and outpatient centers), lodging, private schools, restaurants, retail, warehouses, and commercial miscellaneous.
GOVERNMENT	Government offices, public k-12 schools, and public universities (including technical colleges).
INDUSTRIAL	Energy-intensive manufacturing and (primarily) process-driven customers. This sector includes water and wastewater management.
AGRICULTURAL	Dairy farms, crop farms, and other farms (livestock and greenhouses)

Within these sectors, Cadmus considered multiple market segments, construction vintages (new and existing), and end uses.

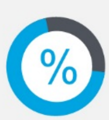
For each sector, Cadmus developed a baseline end-use load forecast that assumed no new future programmatic conservation savings from Focus on Energy. The baseline forecast largely captured savings from building energy codes, equipment standards, and other naturally occurring market forces. Cadmus calculated energy efficiency potential estimates by assessing the impact of each energy conservation measure on this baseline forecast. Therefore, conservation potential estimates presented in this report represent savings that energy efficiency programs could achieve *beyond* the "naturally occurring savings" resulting from the effects of codes, standards, and market forces.

As shown in Figure 1, these methods provided prospective estimates for three different types of savings potential. These estimates were based on standard methods and on information available at the time of the study. This study could not definitively predict the development pace of existing measures or incorporate new measures that may emerge in future years. The study also made assumptions regarding future market conditions and federal/state policies that were based on informed projections but may or may not precisely match actual conditions. Therefore, Cadmus did not design the study results to serve as the final word on savings that can be achieved by Focus on Energy. Rather, this study should be used as a tool to help guide future policy planning, funding, and goal setting, in conjunction with the PSC's Quad planning process and the program design process carried out by Focus on Energy staff.

Figure 1. Types of Potential Estimates

Technical potential includes all technically feasible conservation measures, regardless of costs and market barriers, that are generally available at the time of the study. Cadmus used the industry-standard, bottom-up approach to analyze all electric and natural gas energy efficiency measures applicable to each Focus on Energy sector. This approach remains consistent with energy efficiency potential studies conducted by Cadmus and other consultants throughout the United States.

Economic potential represents a subset of technical potential and consists only of measures that are cost-effective under Focus on Energy's Modified Total Resource Cost (MTRC) test, approved by the PSC.



Achievable potential represents the portion of economic potential that might be reasonably achievable by Focus on Energy, after taking into account market barriers that may impede customer adoption, including limitations in customers' willingness to adopt energy efficiency measures and limitations on the amount of incentives Focus can provide.

This study did not estimate program potential—the amount of potential savings Focus on Energy may realize through the energy efficiency programs it formally offers to customers, and which accounts for program design, spending on energy efficiency programs, and program implementation barriers. Program potential may be lower than achievable potential after accounting for spending limitations and implementation barriers, but it also may be higher than achievable potential after accounting for program options that are not modeled, including incorporation of non-economic measures as part of a program's design. This study does not seek to estimate which design assumptions Focus on Energy will use. Rather, those decisions are better suited to future program planning work. Therefore, although estimates of technical, economic, and achievable potential can serve as valuable starting points for developing program designs and estimating program potential, final estimates of program potential fall outside of this study's scope.

For a more complete discussion of the study's limitations, see this report's section on Considerations and Limitations for Program Design.

Summary of Results

This study quantifies the amount of energy and demand achievable within Focus on Energy's service territory from 2019 to 2030. Table 1 presents electric and natural gas technical, economic, and BAU achievable potential identified through the study. All three potential measurements assume that current Focus on Energy policies will remain in place.

Table 1. Cumulative Energy Efficiency Potential, 2019-2030[1]

Resource	Energy (MWh/Thousand Therms)			Summer Coincident Peak Capacity (MW)		
	Technical Potential	Economic Potential	BAU Achievable Potential	Technical Potential	Economic Potential	BAU Achievable Potential
Electric Energy Efficiency	17,263,454	14,298,668	6,187,133	3,485	2,588	1,090
Natural Gas Energy Efficiency	785,574	502,674	270,506	n/a	n/a	n/a

[1] Table values are reported at the site and not at the generator (e.g., values presented do not include line losses)

In addition, while technical and economic potential reflect overall potential independently of the funding level, the BAU scenario assumes Focus on Energy's funding levels will remain at approximately $100,000,000 per year. After excluding spending on renewables (which falls outside this study's scope) and non-program spending for evaluation and other external oversight, the BAU scenario assumes total spending on energy efficiency programming as $90,000,000 per year.

Energy Efficiency Potential

Study results indicate more than 17,263 cumulative GWh of technically feasible, electric, energy efficiency potential by 2030, with cost-effective measures producing approximately 14,299 GWh. Cumulative savings reflect the sum of annual, incremental savings that can be achieved in each year during the 12-year study period, accounting for equipment turnover based on measure lifetimes.[1] Of Focus on Energy participating utilities' forecasted 2030 sales, technical potential represents 25% and economic potential represents 21%, equating to 2.5% and 2.0% of forecasted sales on an annual basis. As a percentage of total technical potential, the economic potential represents 83%.

This study's cumulative natural gas energy efficiency potential totaled more than 785,574 cumulative thousand therms of technically feasible potential by 2030, with cost-effective measures producing approximately 502,674 thousand therms. The technical potential represents 32% of Focus on Energy participating utilities' forecasted 2030 sales, and economic potential represents 20%, equating to 3.3% and 1.9% of forecasted sales, respectively, on an annual basis. As a percentage of total technical potential, economic potential represents 64%. This report's Technical and Economic Potential section provides detailed estimates of electric and natural gas potential for each sector.

Estimating technical and economic potential requires the broad assumptions that customers either install all technically feasible measures or install all measures that prove technically feasible and cost-effective. Such estimates likely exceed the savings that Focus on Energy can realistically achieve. Estimates of achievable potential not only account for technical constraints and measure cost-effectiveness, they incorporate market adoption barriers, quantified in this study as based on customer incentive levels. Achievable potential is best presented as a range of estimates (rather than as a single-point estimate) that account for various energy efficiency expenditure levels and recognize the uncertainty around customer adoption and the inherent challenges in assessing behavioral factors, which can be difficult to quantify and can change unpredictably over time.

Inclusion of market barriers results in achievable potential estimates that are lower than technical and economic potential estimates. For example, achievable potential recognizes that some customers may not be able to afford the higher upfront costs of energy-efficient measures at lower incentive levels, and some customers may choose not to install energy-efficient measures due to personal tastes. It should, however, be noted that total achievable potential may underestimate Focus on Energy's total program potential, because the potential includes savings only from economic measures (i.e., measures passing Focus on Energy's standard cost-effectiveness test). Focus on Energy requires only that the overall residential and nonresidential portfolios achieve cost-effectiveness, and those cost-effectiveness standards could be met with programs that include some non-economic measures in addition to

[1] These savings potential estimates correspond to annual savings calculations used by Focus on Energy, but they do not correspond to Focus on Energy's additional calculation of lifecycle savings. The program defines lifecycle savings as the total savings from measures installed within a given year over the measure's lifetime. Lifecycle savings from measures installed during the study period often will extend beyond 2030, and they cannot be directly compared to forecasted sales in 2030 or any other given year. These further adjustments could be recognized in calculating program potential estimates. While savings potential does not directly account for lifecycle savings, cost-effectiveness testing recognized these savings, consistent with Focus on Energy's current cost-effectiveness methodology.

economic measures. As such, program potential could be higher for a program design that incorporates additional measures while maintaining program cost-effectiveness.

As shown in Figure 2, Cadmus conducted surveys to assess customers' willingness to adopt energy efficiency measures at four levels (plus BAU). Customers were asked about their willingness to invest in energy efficiency if Focus on Energy subsidized the investment by paying 25% (BAU) up to an annual funding cap of $90,000,000, 25% (total low incentive), 50% (total moderate incentive), 75% (total high incentive), and 100% (total max incentive) of an energy efficiency measure's incremental cost.

Figure 2. Total Achievable Potential Participation Scenarios

Business As Usual	Low Incentive	Moderate Incentive	High Incentive	Max Incentive
25% Incentive + Funding Cap	25% Incentive	50% Incentive	75% Incentive	100% Incentive

As noted, Cadmus calculated a BAU achievable potential scenario, which assumed incentive levels at 25% of incremental measure costs. This most closely matches average 2016 incentive levels across Focus on Energy programs, and further reduces total potential at that incentive level, thus reflecting the amount of program activity that can be carried out at existing funding levels. In the absence of major changes to funding levels or other substantial developments, BAU achievable savings can help inform PSC goals for programs, starting with the upcoming 2019–2022 quadrennial period.

Table 2 shows the BAU, total low incentive, total moderate incentive, total high incentive, and total maximum incentive levels of cumulative, electric, energy efficiency potential that Focus on Energy can expect to achieve during this study's 12-year horizon. Overall savings for BAU, low incentive, moderate incentive, high incentive, and maximum incentive achievable potentials equated to 0.80%, 0.81%, 1.14%, 1.23%, and 1.29%, respectively, of forecasted electric sales on an annual basis. The single-family sector accounted for 33% of the 12-year BAU achievable potential, followed by the industrial sector (30%) and the commercial sector (25%). The multifamily (3.7%), government (5.3%), and agricultural (3.7%) sectors combined to account for the remaining approximately 13%. The report's Achievable Potential section provides detailed estimates of achievable potential for each sector.

Table 2. 12-Year Achievable Electric Energy Efficiency Potential by Sector—Energy (MWh)

Sector	2030 Forecast Sales (MWh)	BAU Achievable Potential (MWh)	Total Low Incentive Achievable Potential (MWh)	Total Moderate Incentive Achievable Potential (MWh)	Total High Incentive Achievable Potential (MWh)	Total Maximum Incentive Achievable Potential (MWh)
Single-Family	17,348,706	2,029,547	2,067,793	2,971,770	3,103,228	3,207,697
Multifamily	2,304,239	230,136	235,327	338,507	357,134	370,523
Commercial	18,005,901	1,525,911	1,591,473	2,186,356	2,357,996	2,474,051
Government	3,106,013	327,019	342,789	423,583	445,895	457,937
Industrial	24,945,991	1,843,413	1,843,413	2,408,800	2,683,332	2,785,060
Agricultural[1]	2,481,154	231,107	231,107	343,991	380,952	397,658
Total	**68,192,004**	**6,187,133**	**6,311,901**	**8,673,007**	**9,328,538**	**9,692,927**

[1] Modeled potential includes agriculture-specific measures. Agricultural program potential may be higher when accounting for general-use electric measures classified in other nonresidential sectors.

The 12-year cumulative achievable scenarios of electric potential range from 6,178 GWh to 9,693 GWh.[2] Average annual achievable electric potential under the BAU scenario during the first four years of the study—corresponding to Focus on Energy's 2019–2022 quadrennial contract period—totals 617,050 MWh per year.

Table 3 shows the BAU, total low incentive, total moderate incentive, total high incentive, and total maximum incentive levels of cumulative, natural gas, energy efficiency potential that Focus on Energy can expect to achieve during this study's 12-year horizon. Changes did not occur for the BAU to low scenarios. Overall savings for BAU, low incentive, moderate incentive, high incentive, and maximum incentive achievable potentials equated to 0.98%, 0.98%, 1.44%, 1.59%, and 1.70%, respectively, of forecasted electric sales on an annual basis. The single-family sector represented 40% of the achievable potential BAU potential, followed by the commercial (28%) and industrial (16%) sectors. This report's Achievable Potential section provides detailed estimates of achievable potential for each sector. The 12-year cumulative achievable scenarios of natural gas potential range from 271 million therms to

[2] Based on 2015 average residential and nonresidential at Wisconsin investor-owned utilities, customer bill savings from achieving all electric achievable potential would range from $599 million for the BAU scenario to $878 million for the total maximum incentive scenario. As actual utility rates will change from 2015 levels, these figures should be considered estimates, useful for illustration purposes, rather than predictions of bill savings that would be achieved.

450 million therms.[3] The average annual achievable natural gas potential under the BAU scenario during the study period's first four years of the study period—corresponding to Focus on Energy's 2019–2022 quadrennial contract period—totals 28,553 million therms per year.

Table 3. 12-Year Achievable Natural Gas Energy Efficiency Potential by Sector—Energy (Thousand Therms)

Sector	2030 Forecast Sales (Thousand Therms)	BAU Achievable Potential (Thousand Therms)	Total Low Incentive Achievable Potential (Thousand Therms)	Total Moderate Incentive Achievable Potential (Thousand Therms)	Total High Incentive Achievable Potential (Thousand Therms)	Total Maximum Incentive Achievable Potential (Thousand Therms)
Single-Family	1,292,521	108,919	108,919	165,206	175,378	183,449
Multifamily	201,299	14,405	14,405	22,289	24,898	27,093
Commercial	560,463	75,661	75,661	105,138	118,138	125,954
Government	135,460	29,224	29,224	38,972	43,393	44,842
Industrial	261,208	42,224	42,224	56,361	63,479	68,297
Agricultural[1]	8,999	73	73	116	146	159
Total	**2,459,950**	**270,506**	**270,506**	**388,082**	**425,432**	**449,794**

[1] Modeled potential includes agriculture-specific measures. Agricultural program potential may be higher when accounting for general-use gas measures classified in other nonresidential sectors.

As part of the study, Cadmus conducted various scenarios, including sensitivity analysis on key cost-effectiveness inputs (e.g., discount rates, carbon values, program budgets, cost-effectiveness tests). The report's Scenario Analysis section summarizes findings from those analyses, with full details provided in Appendix D. As discussed further in the appendix, a scenario that incorporates non-cost-effective measures that have measure-specific modified total resource cost (MTRC) benefit-cost ratios between 0.5 and 1.0 identifies total economic electric potential of 2.3% of annual sales and natural gas potential of 2.8% of annual sales. Compared to the base scenario, which only includes savings from measures with measure-specific benefit-cost ratios greater than 1.0, this scenario increases total economic electric and natural gas potential by 20.7% and 37.4%, respectively. The scenarios would have a similar percentage impact on each total achievable potential scenario, but minimal impact on BAU achievable potential due to the funding cap in that scenario. Because this scenario, as modeled, would still meet Focus on Energy's requirement to maintain overall cost-effectiveness in its residential and nonresidential

[3] Based on 2015's average residential and nonresidential rates at Wisconsin investor-owned utilities, customer bill savings from achieving all natural gas achievable potential would range from $157 million for the BAU scenario to $262 million for the total maximum incentive scenario. As actual utility rates will change from 2015 levels, these figures should be considered estimates for illustration purposes rather than predictions of bill savings that would be achieved.

portfolios, it provides an estimate of the degree to which this factor could affect the difference between total achievable potential and program potential.

Study Comparison

Cadmus compiled results from 12 electric and nine gas energy efficiency potential studies completed during the last four years. In comparing energy efficiency potential study results, it is important to consider the many factors that affect the results, including (but not limited to) these:

- Mix and vintage of segments
- Fuel use patterns
- Energy-management practices
- Certain variations in analytic methods (e.g., the method used to account for local and national codes and standards)

Therefore, results derived from comparisons of this and other studies should be considered indicative rather than conclusive.

Figure 3 shows electric achievable potential as a percentage of baseline sales. For comparison purposes (where possible), Cadmus used potential estimates from a "realistic" potential scenario for each study, consistent with actual program conditions, rather than from the maximum achievable scenario. The figure illustrates that the reviewed studies showed estimated achievable potentials ranging from 6% to 24% (averaging 12%), compared to Focus on Energy's BAU achievable potential of 9%. As many of the other studies did not limit potential calculations based on available funding or incentive levels, and were performed for programs that allowed funding levels higher than Focus on Energy's BAU scenario, results may more directly compare to Focus on Energy's total low incentive and moderate incentive achievable potential scenarios, totaling 9% and 13%, respectively.

As these studies vary by time frames (ranging from 10 to 20 years), another perspective arises from comparing the average annual savings rate of realistic achievable potential. Of the 12 studies, average annual electric savings ranged from 0.3% to 2.1%, with an average of 0.8%.

By comparison, Focus on Energy experiences annual achievable potential of 0.8% under the total low incentive scenario and 1.1% under the moderate incentive achievable scenario.

Figure 3. Realistic Achievable Potential as Percentage of Baseline Electricity Sales

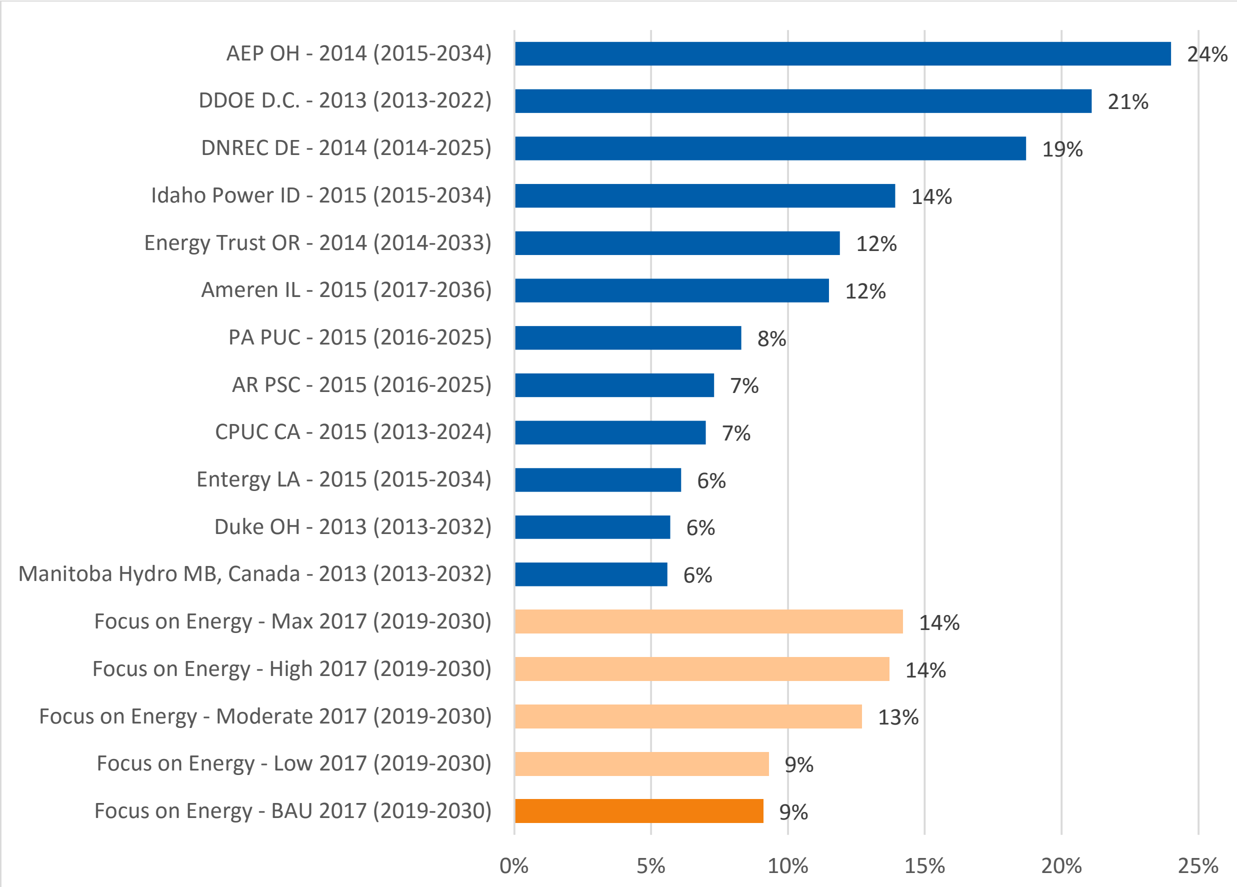
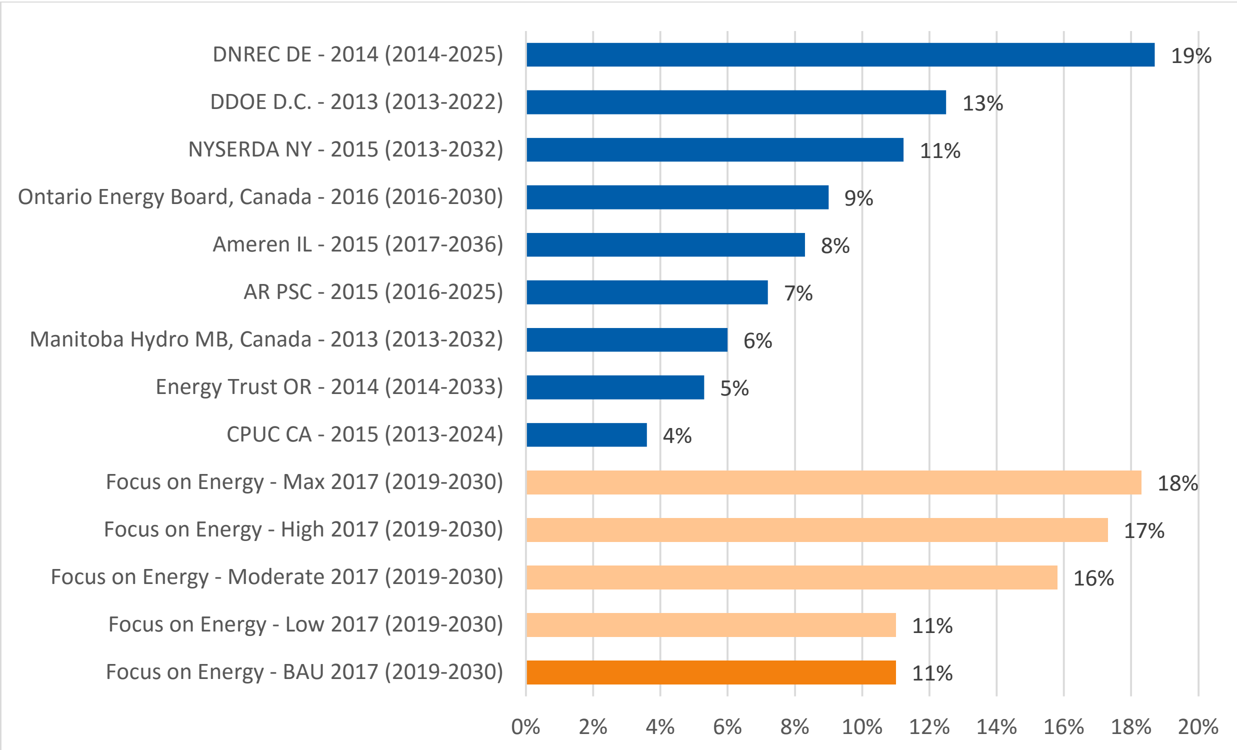


Figure 4 shows realistic natural gas achievable potential as a percentage of baseline sales for this study. The reviewed studies show estimated achievable potentials ranging from 4% to 19% (and averaging 9%), compared to Focus on Energy's BAU achievable potential of 11%, total low achievable incentive potential of 11%, and total moderate incentive achievable potential of 16%.

Another perspective can be attained by comparing the average annual savings rate for the realistic achievable potential. Of the nine natural gas studies, average annual natural gas savings ranged from 0.3% to 1.9%, with an average of 0.7%. This compares to Focus on Energy's BAU average annual natural gas savings rate of 0.9% and to the maximum achievable potential average annual natural gas savings rate of 1.5%. Focus on Energy's low and moderate average annual natural gas savings rates were 0.9% and 1.3%, respectively. Several factors likely contributed to finding that Focus on Energy experiences higher natural gas savings potential than most other jurisdictions listed in Figure 4. For example, a smaller share of customers in some states use natural gas for heating fuel, as opposed to alternatives such as propane and heating oil. In addition, avoided costs of natural gas usage vary based on state conditions and policies, and use of lower avoided costs will identify less economic and achievable potential.

Figure 4. Realistic Achievable Potential as Percentage of Baseline Natural Gas Sales



Program Review and Gap Analysis

Cadmus conducted a benchmarking analysis of energy efficiency program portfolios similar to those of Focus on Energy's to identify best practices and to provide insights for program improvements. The program review compared relevant and available program design and performance information.

On average, benchmarked service territories administered 41% of portfolio spending for residential program delivery. Many service territories offered programs similar in design and delivery mechanisms. All comparison portfolios delivered lighting offers through an upstream design, where customers benefited by purchasing qualified products from participating retailers at a discounted price, with the program reimbursing the retailer. Smart home devices—meters purchased by residential customers to obtain real-time energy feedback and modification—have started to establish a presence within energy efficiency and demand response programs.

On average, the comparison utilities administered 59% of their portfolio spending for nonresidential customers, with all portfolios offering prescriptive, custom, and new construction programs for these customers. Four comparison portfolios offered midstream incentives as part of their lighting offerings, primarily for LED lamp and downlight retrofit lighting measures.

In general, this measure gap analysis revealed that Focus on Energy's portfolio of programs successfully acquired cost-effective energy savings and demand reduction: measures offered in Focus on Energy's current programs aligned well with measures Cadmus identified as having the most potential, including advanced power strips, Wi-Fi thermostats, LED lighting, lighting controls, and variable speed pumps and fans. The study also identified substantial achievable potential from behavioral measures, which Focus on Energy has pursued only through pilot efforts.

As expected, not all emerging technologies proved cost-effective, but some measure iterations (e.g., combinations of fuel savings types, construction vintages, and building segments) passed the cost-effectiveness screen. For example, measures attaining some level of achievable potential included residential heat pump water heaters, residential cold climate heat pumps, residential insulating concrete form construction, residential-sized heat pump clothes dryers, nonresidential HVAC variable refrigerant flows, nonresidential active chilled beam cooling with dedicated outside air systems, and nonresidential gas dryers with modulating controls.

These findings suggest that Focus on Energy could consider offering such measures in future programs. Moreover, as these emerging products progress in the market, costs (ideally) will decrease, making the technology more mainstream as well as improving cost-effectiveness.

This report's Portfolio Benchmarking and Gap Analysis sections provide full details on findings from this analysis.

Organization of this Report

This study's findings are presented in two volumes: this report provides the methodologies and findings of the energy efficiency potential study, the benchmarking study, the gap analysis, study conclusions, and methodological documentation; a separate document contains appendices, including detailed study results and scenario analysis. In conjunction with this study, Cadmus conducted a market transformation potential analysis for select measures using a diffusion theory model. The results are presented in a separate memorandum to avoid misinterpreting and comparing two fundamentally different methodologies.

This report includes the following sections:

Energy Efficiency Potential

- **General Approach** section provides an overview of Cadmus' methodology for estimating technical, economic, and achievable potential. The section includes a discussion of Cadmus' approach to the following:
- **Energy Efficiency Potential** provides detailed sector, segment, and end-use-specific estimates of conservation potential as well as a discussion of the top energy-saving measures in each sector.

Benchmarking and Gap Analysis

- **Portfolio Benchmarking** provides an analysis of other utility jurisdictions' energy efficiency program portfolios and programs similar to those of Focus on Energy's portfolio and program attributes.
- **Gap Analysis** details a comparison of Focus on Energy's energy efficiency measures to the efficiency measures assessed in the potential study.

Conclusions

- **Study Findings** provides a final summary and conclusion
- **Comparisons to Similar Studies** from recent electric and gas energy efficiency potential studies.
- **Program Considerations** providing recommended actions based on report findings

Analysis Methodology

- **Developing Baseline Forecasts** provides an overview of Cadmus' approach to producing baseline end-use forecasts for each sector
- **Measure Characterization** describes Cadmus' approach to developing a database of energy conservation measures, from which Cadmus derived conservation potential estimates
- **Estimating Conservation Potential** discusses assumptions and underlying equations used to calculate technical, economic, and achievable potential
- **Primary Data Collection** describes the comprehensive data collection effort from surveys, site visits, expert interviews, as well as other Wisconsin specific data.

Appendices includes the following sections:

- Appendix A: Baseline Data
- Appendix B: Detailed Assumptions and Energy Efficiency Potential
- Appendix C: Willingness to Adopt Results
- Appendix D: Scenario Analysis
- Appendix E: Benchmarking Sources
- Appendix F: Sector Surveys
- Appendix G: Industrial Expert Interview Results

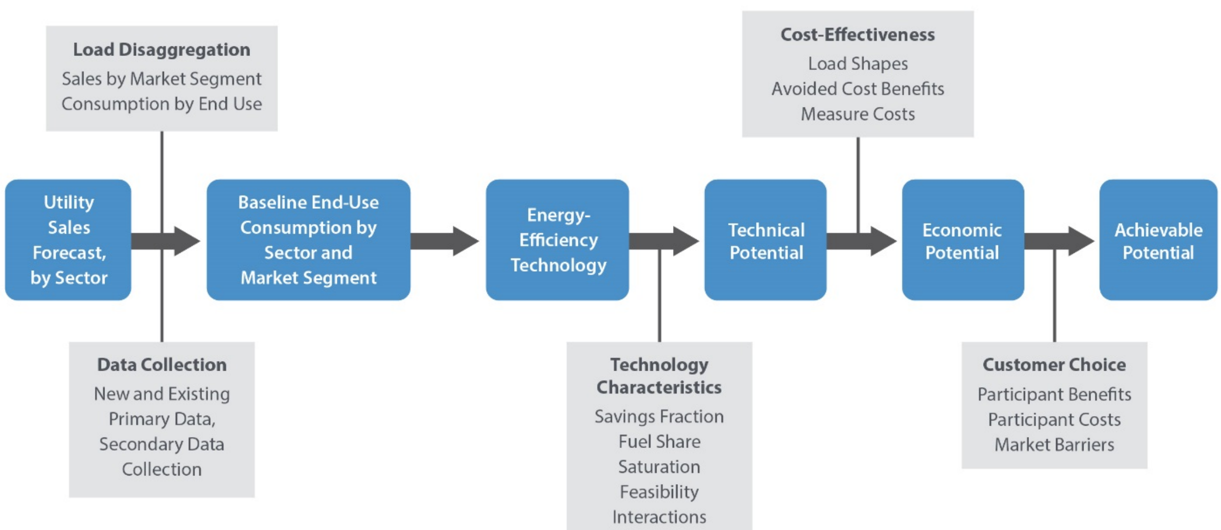
General Approach

This assessment relies on industry best practices, analytic rigor, and flexible and transparent tools to accurately estimate the potential for energy and capacity savings in Focus on Energy's territory from 2019 to 2030. This section describes each step in the assessment process and summarizes the results.

Methodology Overview

Cadmus' general methodology can best be described as a combined "top-down/bottom-up" approach. As shown in Figure 5, the top-down component for this potential study began with the most current participating utility sales forecasts, adjusting for building codes, equipment efficiency standards, and market trends that the forecasts did not account for, and disaggregating this information into customer sectors, customer segments, and end-use components. The bottom-up component considered the potential technical impacts of various energy conservation measures and practices on each end use. Impacts could then be estimated based on engineering calculations and accounting for fuel shares, current market saturations, technical feasibility, and costs.

Figure 5. General Methodology for Assessment of Energy Efficiency Potential



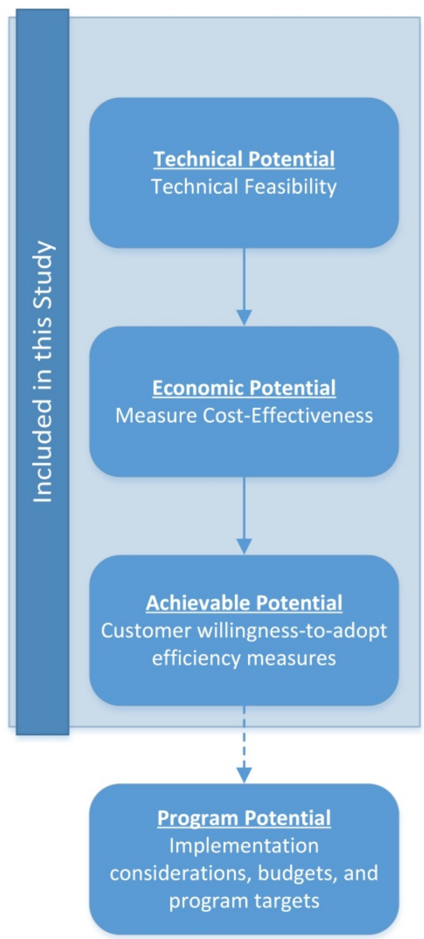
Cadmus developed a baseline forecast by determining 12-year future energy consumption by sector, market segment, and end use. The study calibrated the base year (2019) to Focus on Energy participating utilities' forecasted sector loads. Baseline forecasts in this report include estimates of naturally occurring potential, such as energy savings due to building energy codes and federal equipment standards; therefore, conservation potential estimates presented in the report represent only additional savings achievable through energy efficiency programs.

As part of this study, Cadmus collected primary data across all sectors (residential and nonresidential building stock) within Focus on Energy service territory. Cadmus completed 543 site visits and 1,031 surveys to provide Wisconsin-specific baseline data on building characteristics, demographics, energy-consuming end uses (e.g., fuel type, equipment type, estimate equipment age) and collected information on customers' attitudes towards energy efficiency and willingness to adopt efficiency measures. This report's Analysis Methodology Primary Data Collection section provides further detail on these data collection activities.

Next, Cadmus developed a comprehensive measure database of technical and market data that applied to all end uses in various market segments, and it estimated costs, savings, and applicability for a comprehensive set of energy efficiency measures. The listed measures included existing measures from Focus on Energy programs as well as selected emerging technologies and behavioral measures. This report's Analysis Methodology Measure Characterization section includes a description of data sources used as part of this study.

Figure 6 shows types of potential estimated for this study.

Figure 6. Types of Potential Estimated for this Study



The study assessed the following three types of potential:

1. ***Technical potential*** assumes all technically feasible energy efficiency measures generally available at the time of the study will be implemented, regardless of their costs or of any market barriers. This theoretical upper bound of available conservation potential is estimated after accounting for technical constraints. For energy efficiency resources, technical potential can be divided into three distinct classes:
   - Retrofit opportunities in existing buildings
   - Equipment replacements in existing buildings
   - New construction

   Customers can implement the first class, which exists in current building stock, at any point in the planning horizon. Examples of retrofit measures, which reduce the consumption of end-use equipment without modifying or replacing that equipment, include insulation, faucet aerators, and lighting controls. On the other hand, the potential model assumes that end-use equipment turnover rates and new construction rates dictate the timing of the other two classes. This report's Analysis Methodology Developing Baseline Forecasts section includes a description of data sources Cadmus used to estimate these technical constraints for individual measures.
2. ***Economic potential*** represents a subset of technical potential and consists only of measures meeting the cost-effectiveness criteria, set by the Modified Total Resource Cost (MTRC), approved by the PSC for use as Focus on Energy's primary cost-effectiveness test. For each energy efficiency measure, the study structured the benefit/cost (B/C) test as the ratio of net present values (NPV) for the measure's benefits and costs, using the benefit and cost inputs approved by the PSC for the 2015–2018 quadrennial period. Only measures with a benefit/cost ratio of 1.0 or greater were deemed cost-effective. This report's Analysis Methodology Economic Potential section includes a detailed description of the benefits and costs considered.
3. ***Achievable potential*** derives from the portion of economic potential that might be assumed reasonably achievable in the course of the planning horizon, given market barriers that might impede customer participation in Focus on Energy programs. As measured in this study, achievable potential can vary greatly, based on assumed program incentive levels as well as ramp rates (defined as the acquisition rates for specific technologies) that determine the amount of economic potential considered achievable in each year of the study. Use of different incentive levels reflects that achievable potential can be best presented as a range of estimates (rather than as a single-point estimate). This recognizes the uncertainty around customer adoption and the challenges inherent in assessing behavioral factors, which can be difficult to quantify and can change unpredictably over time. After determining total achievable potential at different incentive levels, Cadmus identified business-as-usual (BAU) achievable potential by adding an assumption that existing Focus on Energy funding levels are maintained, with total funding levels of $100,000,000 per year and energy efficiency program funding of approximately $90,000,000

per year (excluding renewables activity and non-program funding).[4] The Achievable Potential section includes a more detailed discussion of Cadmus' approach in estimating achievable potential.

This report does not consider program potential. Rather, it addresses likely energy savings achievable annually, after accounting for Focus on Energy's current program design components (e.g., measures offered, incentive structures, marketing efforts, program budget constraints) and assuming these design components continue in the future. Achievable potential estimates can inform program potential by estimating program targets' upper and lower bounds and by identifying which measures Focus on Energy can offer to most cost-effectively meet those targets. However, fully estimating program potential requires conducting a more detailed examination of rebate levels, marketing and administration expenditures, and the possible measure mix that Focus on Energy can offer in a portfolio-steps that can be taken in future program-planning processes

After accounting for spending limitations and implementation barriers, program potential may be lower than achievable potential. Program potential, however, also may be higher than achievable potential after accounting for program options, including incorporation of non-economic measures as part of a program's design. For example, Appendix D shows benefit/cost ratios for modeled achievable potential scenarios well above 1.0, indicating additional savings could be achieved by adding savings from non-cost-effective measures while continuing to meet Focus on Energy's portfolio-level cost-effectiveness standards.

Considerations and Limitations for Program Design

While this study provides insights into which measures Focus on Energy could offer in future programs, this information is meant to inform—not set—program targets. In addition to the additional details noted above, several other considerations regarding the design of the potential study may cause future program plans to differ from the study's results:

- **Potential study estimates account for interactions between cost-effective measures**. When installing two interactive measures (e.g., ceiling insulation and windows), the combined interactive savings are lower than the sum of stand-alone savings for the two measures. Sometimes called "measure stacking," such interactive effects can produce lower estimates than planned savings as program plans may not include all measures considered within the potential study.
- **The potential study uses broad assumptions about the adoption of energy efficiency measures with different incentive levels**. Different achievable potential estimates are meant to be directional (i.e., given a certain increase/decrease in incentives, Cadmus would expect a corresponding increase/decrease in savings). This approach provides a realistic range of

[4] Only the BAU achievable scenario includes the annual $90,000,000 spending constraint. The low incentive, moderate incentive, high incentive, and maximum incentive achievable potential scenarios do not include such constraints.

estimates, given a range of incentive levels. Program design, however, requires a more detailed examination of historic participation and incentive levels on a measure-by-measure basis. The potential study can be used to inform planning for measures that Focus on Energy has not historically offered.

- **The potential study only considers cost-effective energy efficiency measures.** It does not consider possible bundling of cost-effective and non-cost-effective measures. Focus on Energy does not require measures to be cost-effective on their own but requires only that the residential and nonresidential portfolios be cost-effective. Programs could be designed so measures, not cost-effective on their own, can be delivered in cost-effective programs and can thereby increase total available savings.
- **The potential study does not consider program implementation barriers.** While it accounts for customers' willingness-to-adopt efficiency measures, it does not examine whether these measures can be delivered through programs. Many programs require robust Trade Ally networks or must overcome barriers such as split incentives to succeed. This study does not account for such barriers.
- **The potential study cannot predict market changes overtime, while programs have flexibility to address market changes.** While this study accounts for changes in codes and standards as they are enacted today, it cannot predict upcoming changes in policies, pending codes and standards, and new technologies to be commercially available. For example, past potential studies may not have accurately predicted the speed and magnitude of recent LED technology adoption. Focus on Energy programs are not static and have the flexibility to address changes in the marketplace.
- **The potential study does not attempt to forecast or otherwise predict future changes in energy efficiency measure costs.** Although the study includes a thorough estimation of incremental energy efficiency measure costs, including equipment, labor, and operations and maintenance (O&M), it does not attempt to forecast changes to these costs during the course of the study. As a result, incremental costs for some emerging technologies, which may decrease with increased adoption, could be overstated relative to actual costs later in the study period.
- **The potential study relies on specified measures, and it may not include highly customized measures provided by programs.** While this study includes a large variety of energy efficiency measures, it is difficult to characterize highly customized measures that may be designed specifically for a single project or building. For example, while the study reviews a number of measures related to defined technologies used in industrial facilities, it does not capture all potential from industrial facility "custom process" measures specific to individual manufacturing processes or facility designs. Given that Focus on Energy has historically achieved substantial savings from industrial custom process projects, achievable potential presented here likely does not fully reflect total program potential in that sector.
- **The potential study does not forecast net-to-gross ratios or make explicit out-of-model adjustments for net-to-gross.** This study develops gross estimates of potential. While the

Program Administrator's goals are based on lifecycle verified gross savings, PSC bases its goals on net annual savings. Therefore, net-to-gross ratios used as a part of the planning process must be established outside of this study.

Stakeholder Involvement

As part of this study, Cadmus facilitated and presented progress updates for PSC stakeholders, through a technical advisory committee (TAC). TAC attendees included Program Administrator, Program Implementers, and Focus on Energy staff, consumer advocate groups, technical experts from implementers, evaluation teams, and other organizations with an interest in this study. These TAC meetings occurred regularly throughout the project, either in-person or via web conferences. While conducting this study, Cadmus held seven TAC meetings.

Throughout the study, supporting stakeholders provided Cadmus with feedback and useful documents that enhanced this study. Where applicable, Cadmus also incorporated feedback and data into the study. As shown in Table 4, Cadmus facilitated and presented progress reports for PSC stakeholders, represented by the TAC.

Table 4. TAC Meetings Summary

Meeting Name	Date	Topics Covered
TAC 1	May 17, 2016	Project schedule, overview of potential study segmentation and how data are used, primary data sample design
TAC 2	June 7, 2016	Measure list, data collection inputs, sample design
TAC 3	June 21, 2016	Behavioral and operational methods, measure list, data collection inputs, sample design, stakeholder comments
TAC 4	January 31, 2017	Primary data results of all sectors
TAC 5	February 21, 2017	Modeling, reporting, and scenario analysis; baseline scenarios
TAC 6	May 4, 2017	Draft technical, economic, and achievable potential
TAC 7	TBD	Final technical, economic, and achievable potential

Technical and Economic Potential

Scope of Analysis

This study included a comprehensive set of conservation measures, including measures from Focus on Energy's technical reference manual (TRM) as well as additional measures not offered by Focus, including new and emerging technologies. Analysis began by assessing the technical potential for hundreds of unique energy efficiency measures. As discussed in the Measure Characterization section, measure savings and costs were separately considered for each measure permutation across applicable sector, segment, end use, and construction vintage. As shown in Table 5, Cadmus considered more than 26,100 energy efficiency measure permutations and 702 unique measures across all sectors and fuels.

Table 5. Measure Counts and Permutations

Sector	Unique Electric Measure Count	Electric Permutations	Unique Natural Gas Measure Count	Natural Gas Permutations
Single-Family	216	1,395	130	747
Multifamily	213 (in-unit) / 161 (common area)	934 (in-unit) / 492 (common area)	119 (in-unit) / 95 (common area)	471 (in-unit) / 259 (common area)
Commercial	286	9,114	133	4,163
Government	281	3,754	133	1,732
Industrial	66	888	20	225
Agricultural	25	42	7	9
Total	**1,248**	**16,619**	**637**	**7,606**

Multifamily sector results throughout the following sections include in-unit apartments and common area potential. The multifamily sector contains residential and nonresidential sales (customer accounts), combined for reporting proposes.

Overview of Results

Table 6 shows baseline sales and cumulative potential by sector. Study results indicated more than 17,263 GWh of technically feasible conservation (25% of baseline sales) by 2030, the end of the 12-year study horizon, with an estimated 14,299 GWh (21% of baseline sales) that are cost-effective and technically feasible (i.e., economic potential). The technical and economic potential equated to electric energy savings as a percentage of sales on an annual basis of 2.5% and 2.0%, respectively. Approximately 83% of the technical potential was economic.

Table 6. Technical and Economic Electric Energy Efficiency Potential by Sector—Energy (MWh)

Sector[1]	2030 Forecast Sales (MWh)	12-Year Technical Potential (MWh)	Technical Potential Percentage of Sales	12-Year Economic Potential (MWh)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Single-Family	17,348,706	7,962,999	46%	6,463,831	37%	81%
Multifamily	2,304,239	811,503	35%	538,822	23%	66%
Commercial	18,005,901	3,584,557	20%	2,971,963	17%	83%
Government	3,106,013	665,007	21%	548,010	18%	82%
Industrial	24,945,991	3,727,323	15%	3,273,532	13%	88%
Agricultural[2]	2,481,154	512,065	21%	502,510	20%	98%
Total	**68,192,004**	**17,263,454**	**25%**	**14,298,668**	**21%**	**83%**

[1] Table values are reported at the site and not at the generator (e.g., values presented do not include line losses).

[2] Modeled potential includes agriculture-specific measures. Agricultural program potential may be higher when accounting for general-use electric measures classified in other nonresidential sectors.

Savings drew on forecasts of future consumption, absent future Focus on Energy program activities. Although these consumption forecasts accounted for past Focus on Energy-funded energy efficiency measures, the identified estimated potential was inclusive of—not in addition to—forecasted program savings. For more details related to the 2030 forecast refer to Developing Baseline Forecasts section.

Table 7 presents cumulative 12-year demand potential from energy efficiency, by sector.[5] Study results indicated approximately 3,485 MW of technically feasible conservation by 2030, with an estimated 2,588 MW of economic demand potential. About 74% of the 12-year technical demand potential was considered economic.

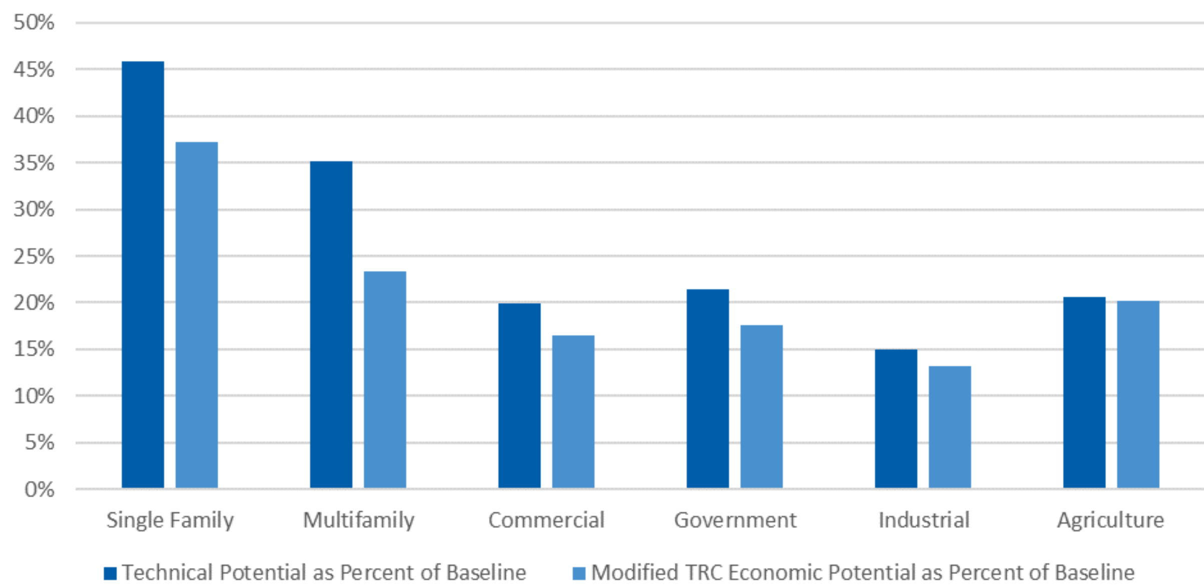
[5] Akin to the potential for energy savings, demand savings potential represents the sum of first-year annual potential savings from each year of the study period. This figure does not repeat annual demand savings already credited to previous years. For example, if a technology can save 1 MW upon installation in 2019, cumulative study period savings for those 2019 installations would be 1 MW. Conversely, if the model indicates another 1 MW in savings can be achieved through new installations during each of the study period's 12 years, the technology's total cumulative savings potential would be 12 MW: 1 MW of newly installed demand savings per year.

Table 7. Technical and Economic Energy Efficiency Potential by Sector—Demand (MW)

Sector	12-Year Technical Potential (MW)	12-Year Economic Potential (MW)	Economic as Percentage of Technical
Single-Family	1,721	1,214	71%
Multifamily	123	47	38%
Commercial	869	667	77%
Government	182	133	73%
Industrial	500	440	88%
Agricultural	90	89	99%
Total	**3,485**	**2,588**	**74%**

Figure 7 shows electric forecast loads and the technical and economic potential as a percentage of forecast loads at the sector level.

Figure 7. Technical and Economic Electric Energy Efficiency Potential as a Percentage of Forecast



The study indicated natural gas energy efficiency potential of more than 785 cumulative million therms of technically feasible, natural gas, energy efficiency potential by 2030, with cost-effective measures producing approximately 503 million therms. Economic potential represented 20% of Focus on Energy participating utilities' forecasted 2030 sales. On an annual basis, the 12-year technical and economic potential savings correspond to savings as a percentage of sales of 3.3% and 1.9%, respectively, considering the effects of compounding.

Table 8 summarizes natural gas technical and economic cumulative potential for each sector. The single-family sector accounted for 40% of the total economic natural gas potential, followed by the commercial sector, which accounted for 29%.

Table 8. Technical and Economic Natural Gas Energy Efficiency Potential by Sector—Energy (Thousand Therms)

Sector[1]	2030 Forecast Sales (Thousand Therms)	12-Year Technical Potential (Thousand Therms)	Technical Potential Percentage of Sales	12-Year Economic Potential (Thousand Therms)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Single-Family	1,292,521	401,047	31%	201,043	16%	50%
Multifamily	201,299	53,978	27%	31,543	16%	58%
Commercial	560,463	192,371	34%	143,737	26%	75%
Government	135,460	59,290	43%	47,762	35%	82%
Industrial	261,208	78,415	30%	78,415	30%	100%
Agricultural[2]	8,999	1,473	16%	173	2%	12%
Total	**2,459,950**	**785,574**	**32%**	**502,674**	**20%**	**64%**

[1] Table values are reported at the site and not at the generator (e.g., values presented do not include line losses).

[2] Modeled potential includes agriculture-specific measures. Agricultural program potential may be higher when accounting for general-use electric measures classified in other nonresidential sectors.

Residential

Residential customers in Focus on Energy's territory accounted for 29% of electric baseline forecast sales. The sector, divided into single-family, manufactured homes, and multifamily homes, presents a variety of potential savings sources, including general and specialty LED lighting, removal of secondary refrigerators, smart strip plug outlets, and heat pump dryers.

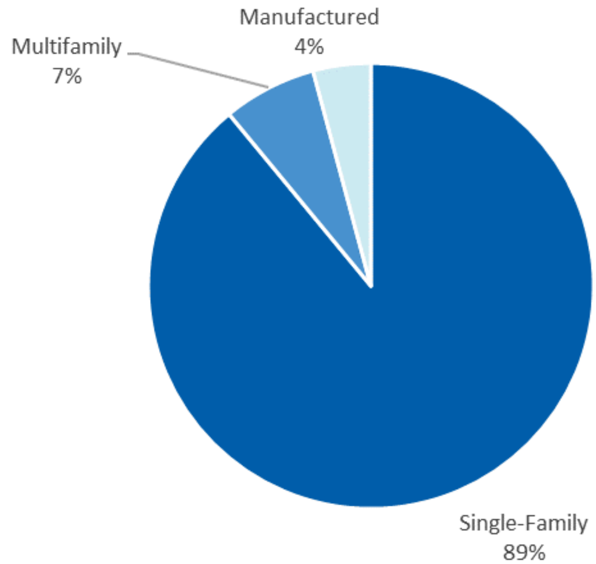
Based on resources included in this assessment, Cadmus estimated residential cumulative economic potential of approximately 7,002,653 MWh over 12 years, corresponding to a 36% reduction in residential baseline sales by 2030. Table 9 shows cumulative 12-year residential conservation potential by residential segment.

Table 9. Residential Electric Technical and Economic Energy Efficiency Potential by Segment

Segment	2030 Forecast Sales (MWh)	12-Year Technical Potential (MWh)	Technical Potential Percentage of Sales	12-Year Economic Potential (MWh)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Single-Family and Manufactured Homes	17,348,706	7,962,999	46%	6,463,831	37%	81%
Multifamily	2,304,239	811,506	35%	538,822	23%	66%
Total	**19,652,945**	**8,774,502**	**45%**	**7,002,653**	**36%**	**80%**

As shown above and in Figure 8, single-family homes accounted for 89% (6,173,509 MWh) of residential economic potential, multifamily homes accounted for 7% (471,430 MWh), and manufactured homes accounted for 4% (290,322 MWh).

Figure 8. Residential Electric Economic Potential by Segment, 2030



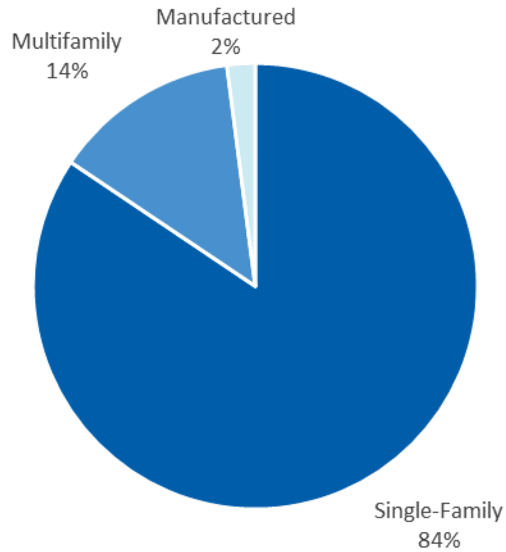
Based on resources included in this assessment, Cadmus estimated residential natural gas cumulative economic potential of approximately 232 million therms over 12 years, corresponding to a 30% reduction in residential baseline sales by 2030. Table 10 shows cumulative 12-year residential natural gas conservation potential by residential segment.

Table 10. Residential Natural Gas Technical and Economic Energy Efficiency Potential by Segment

Segment	2030 Forecast Sales (Thousand Therms)	12-Year Technical Potential (Thousand Therms)	Technical Potential Percentage of Sales	12-Year Economic Potential (Thousand Therms)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Single-Family and Manufactured Homes	1,292,521	401,047	31%	201,043	16%	50%
Multifamily	201,299	53,978	27%	31,543	16%	58%
Total	**1,493,821**	**455,025**	**30%**	**232,586**	**16%**	**51%**

As shown above and in Figure 9, single-family homes accounted for 84% of residential natural gas cumulative economic potential, multifamily homes accounted for 14%, and manufactured homes accounted for 2%.

Figure 9. Residential Natural Gas Economic Potential by Segment, 2030



The lighting, plug load, and refrigeration end uses combined to account for 63% of the electric residential cumulative technical potential (shown in Table 11 and Figure 10) and 70% of the cumulative economic potential (shown in Table 11 and Figure 11).

Table 11. Residential Electric Technical and Economic Energy Efficiency Potential by End-Use Group

End-Use Group	2030 Forecast Sales (MWh)	12-Year Technical Potential (MWh)	Technical Potential Percentage of Sales	12-Year Economic Potential (MWh)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Lighting	3,267,183	2,437,609	75%	2,260,342	69%	93%
Refrigeration	2,334,233	1,492,581	64%	1,495,450	64%	100%
Plug Load	5,292,167	1,566,686	30%	1,119,070	21%	71%
Water Heat	1,880,917	1,086,728	58%	910,021	48%	84%
Cooling	1,839,484	770,142	42%	457,235	25%	59%
Dryer	1,575,801	737,085	47%	402,051	26%	55%
Ventilation	1,806,166	369,286	20%	152,373	8%	41%
Pool Pump	235,488	140,541	60%	140,524	60%	100%
Heating	533,762	151,939	28%	53,867	10%	35%
Cooking	887,744	21,907	2%	11,721	1%	54%
Total	**19,652,945**	**8,774,502**	**45%**	**7,002,653**	**36%**	**80%**

Figure 10. Residential Electric Technical Energy Efficiency Potential by End-Use Group

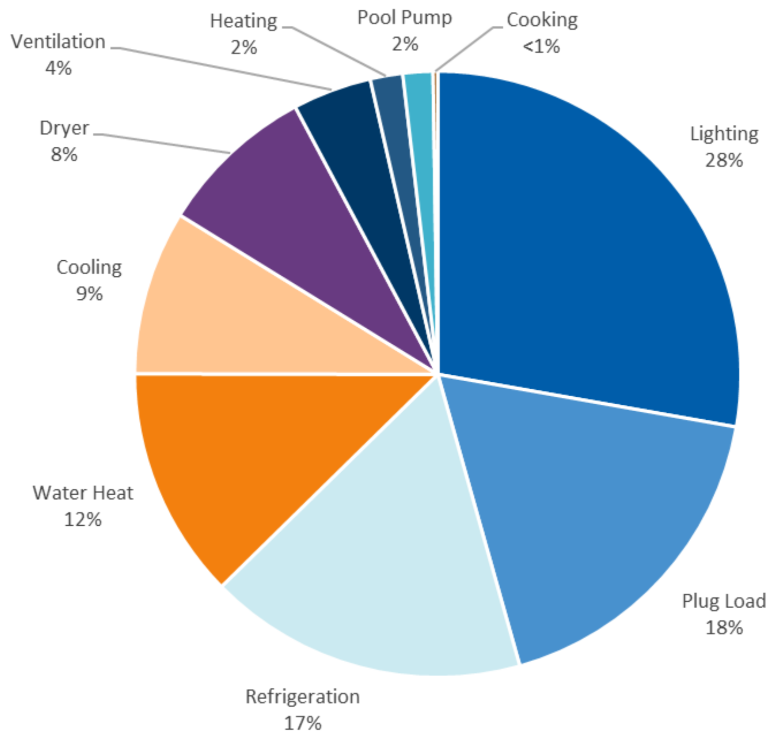
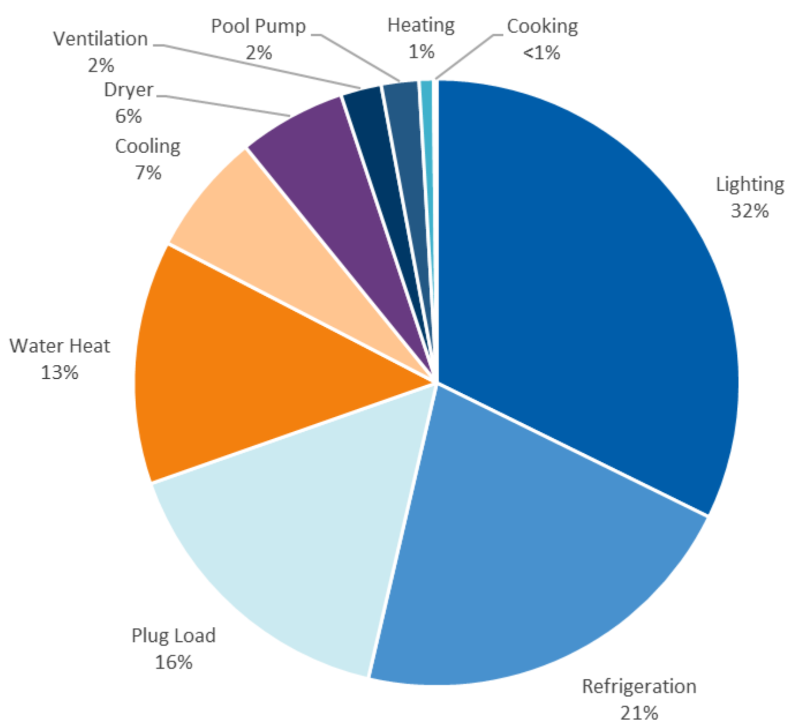


Figure 11. Residential Electric Economic Energy Efficiency Potential by End-Use Group



The heat central gas furnace and water heating end uses accounted for 62% and 26% of residential natural gas cumulative technical potential, respectively, as shown in Table 12 and Figure 12. These two end uses combined to account for approximately 87% of the cumulative economic potential, as shown in Table 12 and Figure 13.

Table 12. Residential Natural Gas Technical and Economic Energy Efficiency Potential by End-Use Group

End-Use Group	2030 Forecast Sales (Thousand Therms)	12-Year Technical Potential (Thousand Therms)	Technical Potential Percentage of Sales	12-Year Economic Potential (Thousand Therms)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Heat Central Gas Furnace[1]	1,047,066	285,113	27%	115,917	11%	41%
Water Heat	240,729	116,606	48%	87,189	36%	75%
Heat Central Gas Boiler[1]	182,128	50,306	28%	28,420	16%	56%
Cooking	13,207	1,481	11%	942	7%	64%
Dryer	10,690	1,519	14%	119	1%	8%
Total	**1,493,821**	**455,025**	**30%**	**232,586**	**16%**	**51%**

[1] End use includes multifamily whole building and common areas.

Figure 12. Residential Natural Gas Technical Energy Efficiency Potential by End-Use Group

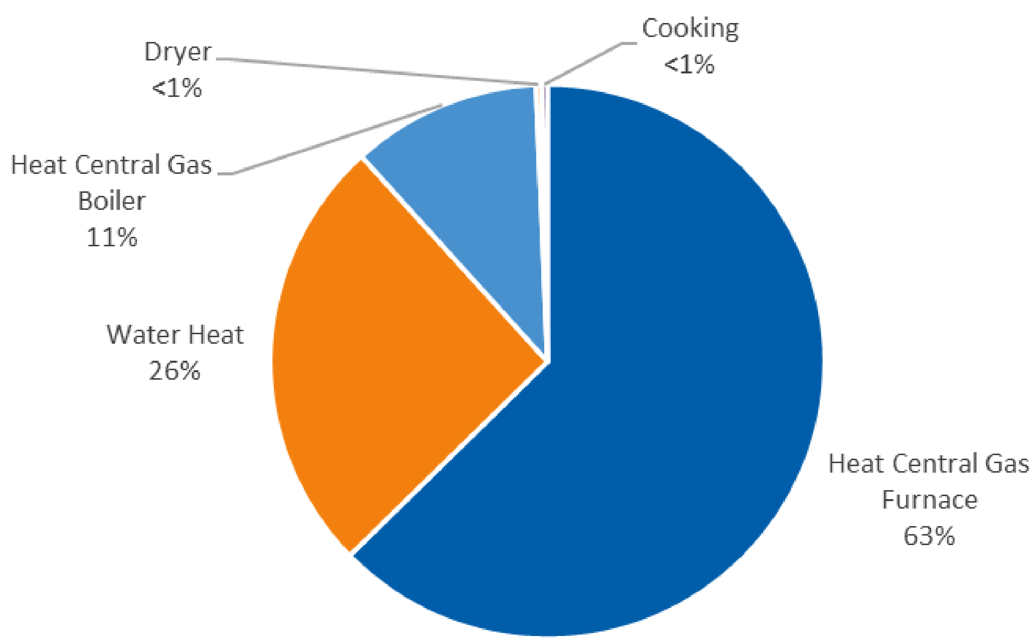
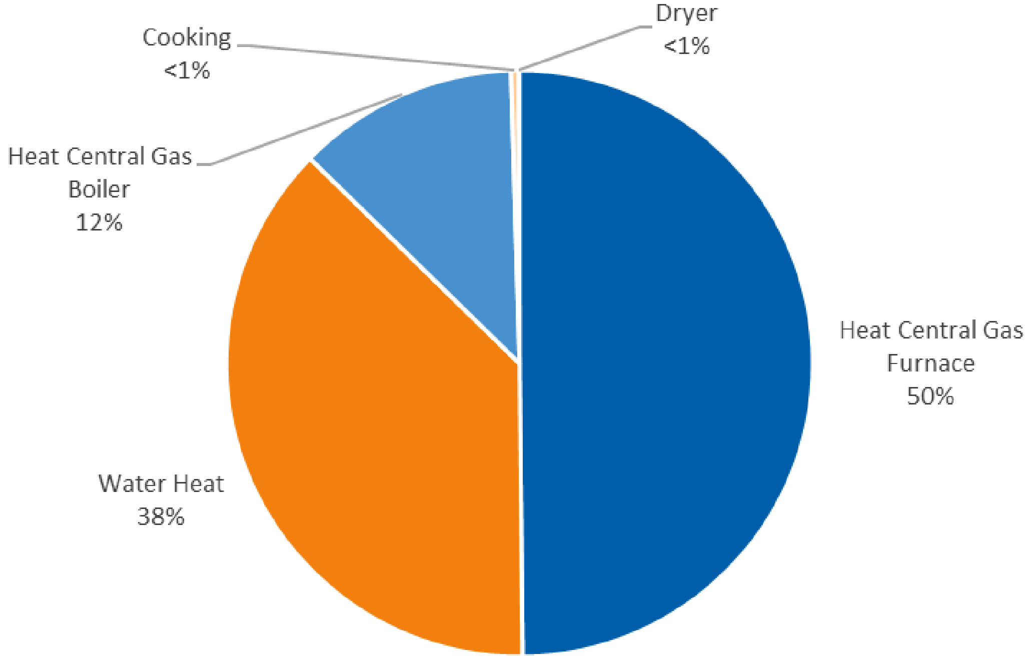


Figure 13. Residential Natural Gas Economic Energy Efficiency Potential by End-Use Group



Specialty LED lighting and removal of secondary refrigerators represented the top two energy-saving electric residential measures, respectively. Table 13 lists the top 15 saving electric residential measures.

Table 13. Top Electric Energy Efficiency Saving Residential Measures

Residential Energy Efficiency Measure	12-Year Cumulative Economic Potential (MWh)	Percentage of Total Residential Economic Potential
Lighting Specialty Lamp - Premium Efficiency LED	1,310,782	18.9%
Refrigerator - Removal of Secondary	1,031,782	14.9%
Lighting General Service Lamp - Premium Efficiency LED	755,992	10.9%
Smart Strip Plug Outlet	656,194	9.5%
Dryer - Heat Pump Dryer	397,542	5.7%
Freezer - Removal of Stand-Alone	347,505	5.0%
Central Air Conditioner - Enhanced	214,319	3.1%
Low-Flow Showerhead	211,312	3.0%
TV - ENERGY STAR®	181,743	2.6%
Faucet Aerator Low Flow - Kitchen	153,104	2.2%
Motor - ECM	141,425	2.0%
Pool Pump - VSD	114,074	1.6%
Heat Pump Water Heater - Advanced Efficiency	105,146	1.5%
Heat Pump Water Heater - Enhanced Efficiency	98,988	1.4%
Refrigerator – CEE Tier 2	97,382	1.4%

General and specialty LED lighting, removal of secondary refrigerators, smart strip plug outlets, and heat pump dryers comprised the top five electric energy-saving residential measures, which collectively accounted for 60% of the 12-year residential economic potential. Note that Table 13 includes only measures that passed the MTRC B/C screen. Though $C0_2$ heat pump water heaters, ENERGY STAR Most Efficient TVs,[6] and interior lighting occupancy sensors displayed more technical potential than some of the top electric energy-saving economic measures, these were not cost-effective from an MTRC perspective. As mentioned earlier, the economic results represented here are not intended to translate directly to program potential. Rather, they provide an indicator of available economic potential. Complete measure details including cost-effectiveness screening results can be found in Appendix B.

Low-flow showerheads and Wi-Fi thermostats represented the top two natural gas energy-saving residential measures, respectively. Table 14 lists the top 15 saving residential natural gas measures.

Table 14. Top Natural Gas Energy Efficiency Saving Residential Measures

Residential Energy Efficiency Measure	12-Year Cumulative Economic Potential (Thousand Therms)	Percentage of Total Residential Economic Potential
Low-Flow Showerhead	37,423	16.9%
Wi-Fi Thermostat	29,159	13.2%
Faucet Aerator Low Flow - Kitchen	22,592	10.2%
Duct Sealing and Insulation - WI UDC Zone 1 and 2 Code	22,494	10.2%
Furnace - Premium Efficiency	16,263	7.4%
Energy Feedback Residential - HVAC Schedule Setback	14,839	6.7%
Faucet Aerator Low Flow - Bathroom	13,660	6.2%
Wi-Fi Thermostat - Seasonal Savings	12,039	5.5%
Programmable Thermostat	11,113	5.0%
Door - WI UDC Zone 1 and 2 Above Code	10,544	4.8%
Floor Insulation - WI UDC Zone 1 Code	6,574	3.0%
Energy Feedback Residential - Water Heat Temperature Setback	6,021	2.7%
Pipe Insulation - Boiler - Code	5,910	1.3%
Infiltration Control - Reduction of Existing Conditions	2,850	1.2%
Clothes Washer (Front Loading) - CEE Tier 3	2,647	1.0%

In addition to low-flow showerheads and Wi-Fi thermostats, kitchen faucet aerators, duct sealing and insulation, and premium efficiency furnaces comprised the top five natural gas energy-saving measures, which combined to account for 58% of the 12-year natural gas residential economic potential.

[6] While ENERGY STAR Most Efficiency TVs were not cost-effective, other efficiency tiers for TVs did pass the cost-effectiveness screen.

Commercial and Government

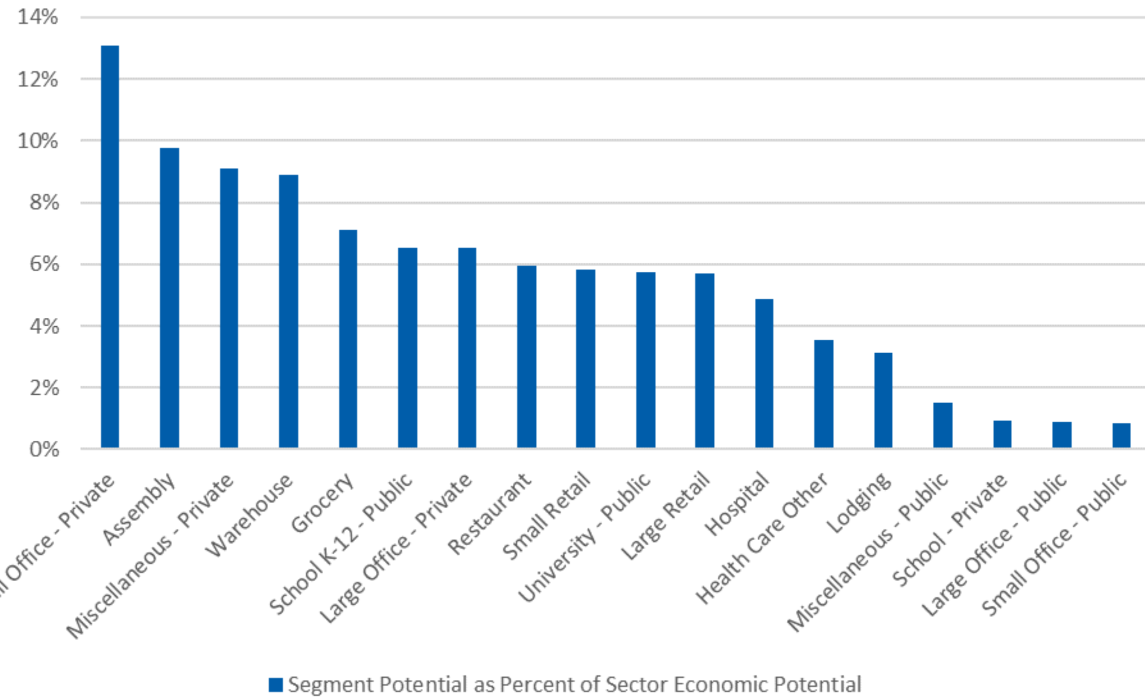
Focus on Energy participating utilities' commercial and government sector accounted for 31% of baseline sales in 2030 and 38% of total economic potential. Cadmus estimated potential for the 18 commercial and government segments listed in Table 15, which also summarizes 2030 forecast sales, 12-year cumulative technical and economic potential, and the same potentials as a percentage of sales.

Table 15. Commercial and Government Technical and Economic Electric Energy Efficiency Potential by Segment

Segment	2030 Forecast Sales (MWh)	12-Year Technical Potential (MWh)	Technical Potential Percentage of Sales	12-Year Economic Potential (MWh)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Small Office – Private	3,309,486	585,626	18%	460,134	14%	79%
Assembly	1,072,023	395,850	37%	343,603	32%	87%
Miscellaneous – Private	1,836,896	403,937	22%	319,788	17%	79%
Warehouse	1,844,000	395,565	21%	313,546	17%	79%
Grocery	1,536,173	274,380	18%	250,941	16%	91%
School K-12 – Public	1,160,810	284,341	24%	229,669	20%	81%
Large Office – Private	1,422,946	265,778	19%	229,639	16%	86%
Restaurant	1,431,616	239,824	17%	209,935	15%	88%
Small Retail	1,352,441	257,743	19%	204,738	15%	79%
University – Public	1,239,611	240,207	19%	202,701	16%	84%
Large Retail	1,239,025	246,963	20%	200,039	16%	81%
Hospital	1,270,241	203,519	16%	171,481	13%	84%
Health Care Other	867,055	142,578	16%	125,103	14%	88%
Lodging	667,980	133,824	20%	110,076	16%	82%
Miscellaneous – Public	309,011	66,500	22%	53,765	17%	81%
School – Private	155,721	38,971	25%	32,939	21%	85%
Large Office – Public	186,520	36,216	19%	31,623	17%	87%
Small Office – Public	210,061	37,743	18%	30,252	14%	80%
Total	**21,111,914**	**4,249,564**	**20%**	**3,519,973**	**17%**	**83%**

Private small offices, assemblies (including churches, theaters, gymnasiums, etc.), private miscellaneous (including a broad range of commercial businesses that either do not fit into another commercial building type or are generally unclassifiable), and warehouse buildings combined to account for 42% and 41% of electric commercial and government sector cumulative technical and economic potential, respectively, as shown in Figure 14.

Figure 14. Commercial and Government Economic Electric Energy Efficiency Potential by Segment



Focus on Energy participating utilities' commercial and government sector accounted for 28% of baseline natural gas sales in 2030 and 38% of total economic potential. Cadmus estimated natural gas potential for the same 18 commercial and government segments for which electric potential was estimated, as shown in Table 16 (which also summarizes 2030 forecast sales, 12-year cumulative technical and economic potential, and the same potentials as a percentage of sales).

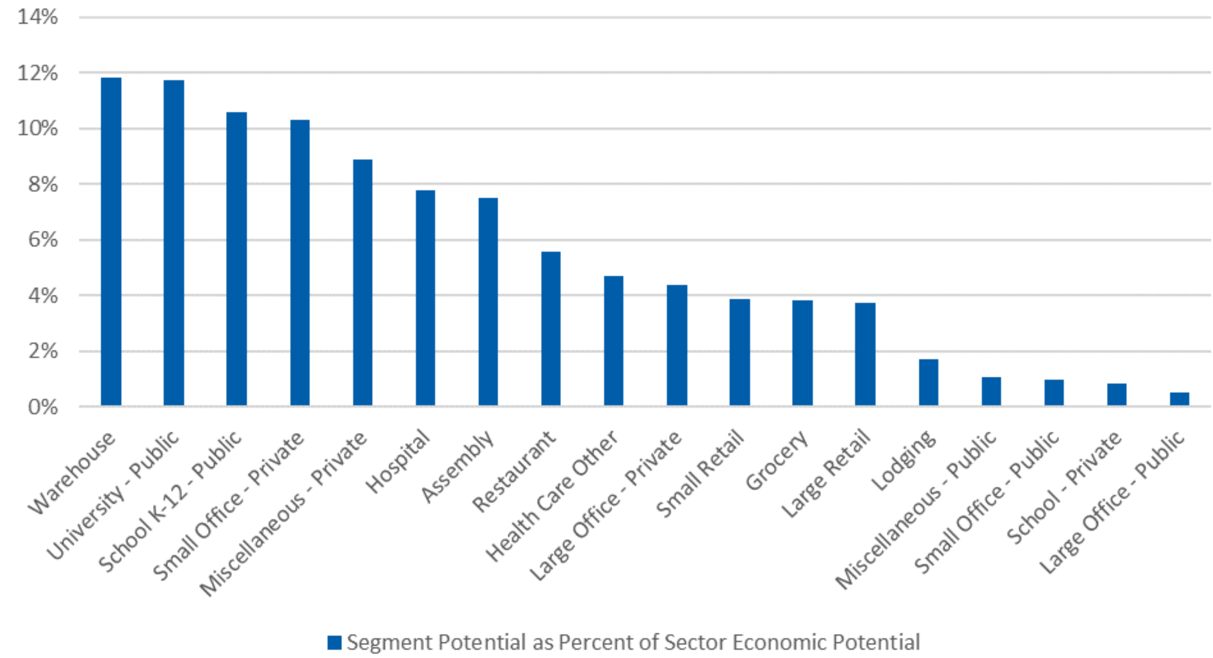
Table 16. Commercial and Government Technical and Economic Natural Gas Energy Efficiency Potential by Segment

Segment	2030 Forecast Sales (Thousand Therms)	12-Year Technical Potential (Thousand Therms)	Technical Potential Percentage of Sales	12-Year Economic Potential (Thousand Therms)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Warehouse	88,222	36,097	41%	22,626	26%	63%
University - Public	54,451	23,974	44%	22,508	41%	94%
School K-12 - Public	61,403	27,553	45%	20,271	33%	74%
Small Office - Private	91,174	22,663	25%	19,726	22%	87%
Miscellaneous - Private	61,107	24,233	40%	17,061	28%	70%
Hospital	41,001	15,762	38%	14,923	36%	95%
Assembly	51,531	21,784	42%	14,423	28%	66%

Segment	2030 Forecast Sales (Thousand Therms)	12-Year Technical Potential (Thousand Therms)	Technical Potential Percentage of Sales	12-Year Economic Potential (Thousand Therms)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Restaurant	50,698	11,715	23%	10,691	21%	91%
Health Care Other	31,358	9,758	31%	9,011	29%	92%
Large Office - Private	39,049	15,170	39%	8,410	22%	55%
Small Retail	28,943	8,112	28%	7,470	26%	92%
Grocery	22,956	7,550	33%	7,296	32%	97%
Large Retail	25,912	10,449	40%	7,119	27%	68%
Lodging	22,827	6,677	29%	3,324	15%	50%
Miscellaneous - Public	7,255	2,923	40%	2,084	29%	71%
Small Office - Public	7,950	2,075	26%	1,868	23%	90%
School - Private	5,683	2,402	42%	1,656	29%	69%
Large Office - Public	4,401	1,765	40%	1,031	23%	58%
Total	**695,922**	**250,661**	**36%**	**191,500**	**28%**	**76%**

Private small offices, assemblies, private miscellaneous, and warehouse buildings combined to account for 42% and 41% of natural gas commercial and government sector cumulative technical and economic potential, respectively, as shown in Figure 15.

Figure 15. Commercial and Government Economic Natural Gas Energy Efficiency Potential by Segment



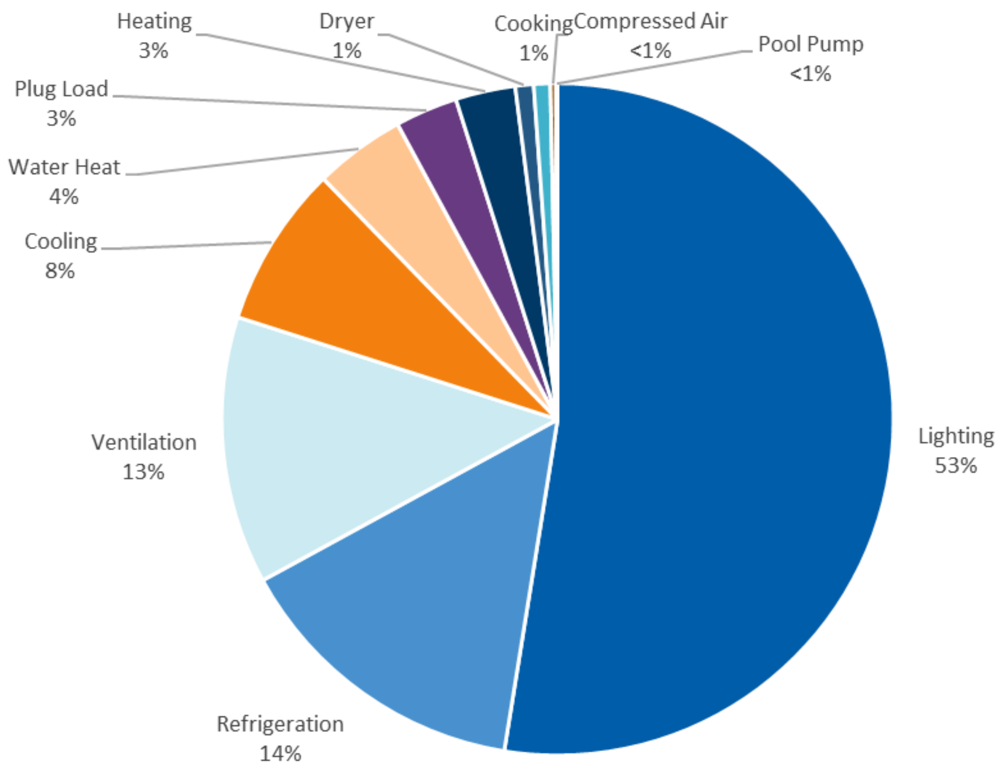
Across each of these segments, lighting represented the largest electric savings potential, accounting for approximately 53% of the commercial and government electric economic potential. Although the plug load end use accounted for approximately 30% of 2030 commercial forecast sales, the relatively few energy efficiency measures applied to this end use resulted in technical potential equal to only 2% of forecast sales. Table 17 shows 2030 baseline sales, 12-year cumulative technical and economic potential, and those potentials as a percentage of baseline sales. Figure 16 shows the distribution of 12-year economic potential by end use.

Table 17. Commercial and Government Technical and Economic Electric Energy Efficiency Potential by End Use

End-Use Group	2030 Forecast Sales (MWh)	12-year Technical Potential (MWh)	Technical Potential Percentage of Sales	12-year Economic Potential (MWh)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Lighting	6,517,302	2,123,444	33%	1,849,503	28%	87%
Refrigeration	2,432,933	554,421	23%	510,847	21%	92%
Ventilation	2,888,075	601,946	21%	452,867	16%	75%
Cooling	790,503	434,092	55%	274,264	35%	63%
Water Heat	301,611	163,593	54%	154,007	51%	94%
Plug Load	6,343,106	133,820	2%	106,072	2%	79%
Heating	506,525	117,366	23%	101,324	20%	86%
Dryer	175,861	34,740	20%	30,948	18%	89%

End-Use Group	2030 Forecast Sales (MWh)	12-year Technical Potential (MWh)	Technical Potential Percentage of Sales	12-year Economic Potential (MWh)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Cooking	521,314	28,115	5%	28,115	5%	100%
Compressed Air	620,191	54,647	9%	9,246	1%	17%
Pool Pump	14,493	3,381	23%	2,779	19%	82%
Total	**21,111,914**	**4,249,564**	**20%**	**3,519,973**	**17%**	**83%**

Figure 16. Commercial and Government Electric Economic Energy Efficiency Potential by End-Use Group

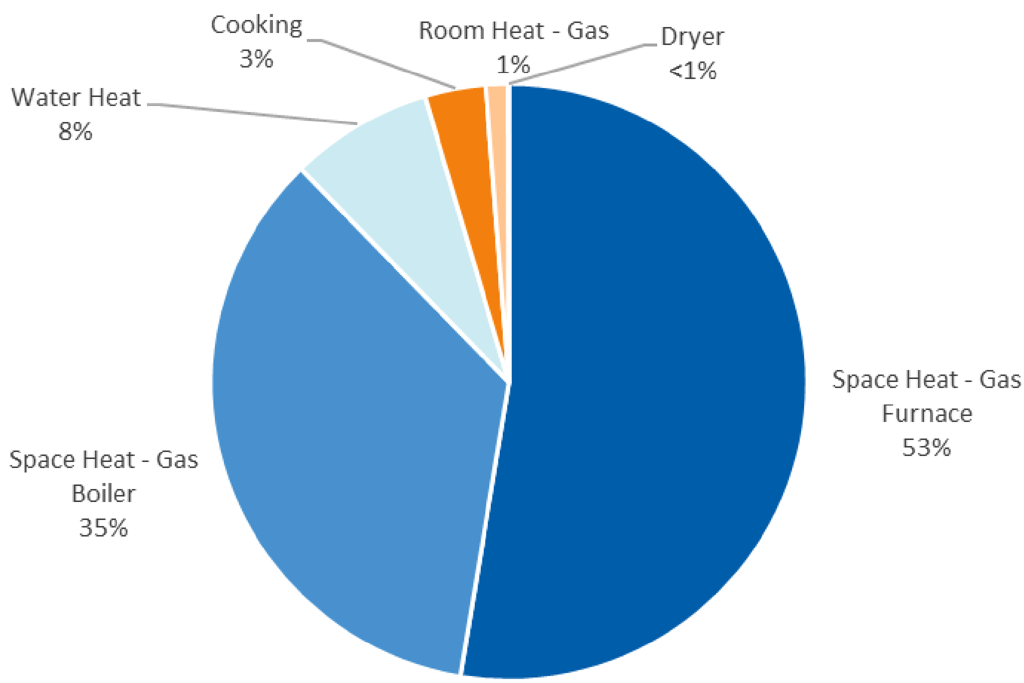


Across each of these segments, the space heat - gas furnace end use accounted for the majority of natural gas savings, representing 53% of economic potential, followed by space heat - gas boiler, which accounted for 35%. Table 18 shows 2030 baseline sales, 12-year cumulative technical and economic potential, and those potentials as a percentage of baseline sales. Figure 17 shows the distribution of 12-year cumulative economic potential by end use.

Table 18. Commercial and Government Technical and Economic Natural Gas Energy Efficiency Potential by End Use

End-Use Group	2030 Forecast Sales (Thousand Therms)	12-year Technical Potential (Thousand Therms)	Technical Potential Percentage of Sales	12-year Economic Potential (Thousand Therms)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Space Heat - Gas Furnace	384,954	140,825	37%	100,749	26%	72%
Space Heat - Gas Boiler	185,290	80,962	44%	67,203	36%	83%
Water Heat	49,930	17,753	36%	14,837	30%	84%
Cooking	38,720	6,520	17%	6,323	16%	97%
Room Heat - Gas	35,647	4,423	12%	2,334	7%	53%
Dryer	1,383	178	13%	54	4%	30%
Total	**695,922**	**250,661**	**36%**	**191,500**	**28%**	**76%**

Figure 17. Commercial and Government Natural Gas Economic Energy Efficiency Potential by End-Use Group



Occupancy sensor controls, interior linear TLED lighting, and screw base LEDs combined to represent approximately one-third of the total commercial and government electric savings potential. Table 19 lists the top 15 saving commercial and government measures, which accounted for 62% of the electric commercial economic potential.

Table 19. Top Commercial and Government Electric Energy Efficiency Measures

Commercial and Government Energy Efficiency Measure	12-Year Cumulative Economic Potential (MWh)	Percentage of Total Commercial and Government Economic Potential
Occupancy Sensor Control	494,297	13.8%
Lighting Interior - TLED - Above Standard	493,744	13.8%
Lighting Interior - Screw Base LED - Above Standard	251,819	7.0%
Walk-in Economizer	113,523	3.2%
Parking - Surface Lighting	112,577	3.1%
Convert Constant Volume Air System to VAV	97,316	2.7%
Glass Door ENERGY STAR Refrigerators/Freezers	96,254	2.7%
Fan System - HVAC - Variable Speed Control	91,769	2.6%
Motor - VAV Box High Efficiency (ECM)	81,221	2.3%
LED or equivalent sign lighting	80,870	2.3%
LED Exterior Flood Lights	71,995	2.0%
New Construction Lighting Package - Advanced Efficiency	64,594	1.8%
Water Heater LE 55 Gal - CO2 Heat Pump	62,424	1.7%
Exit Sign - LED	59,969	1.7%
Direct Digital Control System-Installation	53,607	1.5%

In addition to the measures listed in Table 19, LED exterior wall packs (136,017 MWh), bi-level control stairwell lighting (58,718 MWh), LED exterior pole mount fixtures (41,026 MWh), and variable frequency drive (VFD) air compressor upgrades (39,331 MWh) were measures for which technical potential was greater than many of the commercial and government measures in the study but these were not cost-effective from an MTRC perspective.

Direct digital control systems (e.g., building energy management systems) and Wi-Fi thermostats accounted for almost 36% of the total natural gas savings for commercial and government sectors. Table 20 lists the top 15 saving commercial and government measures.

Table 20. Top Commercial and Government Natural Gas Energy Efficiency Measures

Commercial and Government Energy Efficiency Measure	12-Year Cumulative Economic Potential (Thousand Therms)	Percentage of Total Commercial and Government Economic Potential
Direct Digital Control System-Installation	38,864	19.1%
Wi-Fi Thermostat	34,037	16.8%
Integrated Space Heating and Water Heating	9,854	4.9%
Duct Repair and Sealing	9,432	4.6%
Automated Ventilation VFD Control (Occupancy Sensors/ CO_2 Sensors)	9,099	4.5%

Commercial and Government Energy Efficiency Measure	12-Year Cumulative Economic Potential (Thousand Therms)	Percentage of Total Commercial and Government Economic Potential
Furnace < 225 kBtuh - Advanced Efficiency	8,183	4.0%
Insulation - Ceiling - IECC 2015 - Zone 6 Code	7,742	3.8%
Insulation - Wall - IECC 2015 - Zone 6 and 7 Above Code	6,613	3.3%
Insulation - Ceiling - IECC 2015 - Zone 6 Above Code	5,737	2.8%
Boiler Draft Fan - VFD	5,707	2.8%
Recommissioning	5,669	2.8%
Infiltration Reduction	5,528	2.7%
Boiler - Economizer	4,993	2.5%
Water Heater Setback Thermostat	4,636	2.3%
Retrocommissioning	4,562	2.2%

The measures listed in Table 20 all passed the MTRC screen for economic potential. Measures not passing that screen, for which technical potential was higher than many government and commercial sector measures that were found to be economic, include exhaust air-to-ventilation air heat recovery, continuous commissioning, and strategic energy management. While both retro-commissioning and recommissioning exhibit cost-effective potential in Table 20, the applications of these measures were cost-effective in only a fraction of end-use and building type combinations because the technical potential for retro-commissioning and recommissioning was over 27 million and 26 million therms, respectively; the percentage of technical potential that was economic for retro-commissioning is only 17% and for recommissioning is 21%.

Industrial

Cadmus estimated energy efficiency potential for the industrial manufacturing sector using a wide range of measures culled from multiple sources. Cadmus assessed energy efficiency potential for 15 industrial segments in Focus on Energy's service territory, based on allocations from Focus on Energy participating utilities' nonresidential customer databases. In addition to these industrial segments, this study considered wastewater treatment facilities, water pumping and treatment facilities, and street lighting within the framework of the industrial sector, primarily because energy consumption in these segments was process-based and did not occur within a specific building type (as in the commercial and government sector).

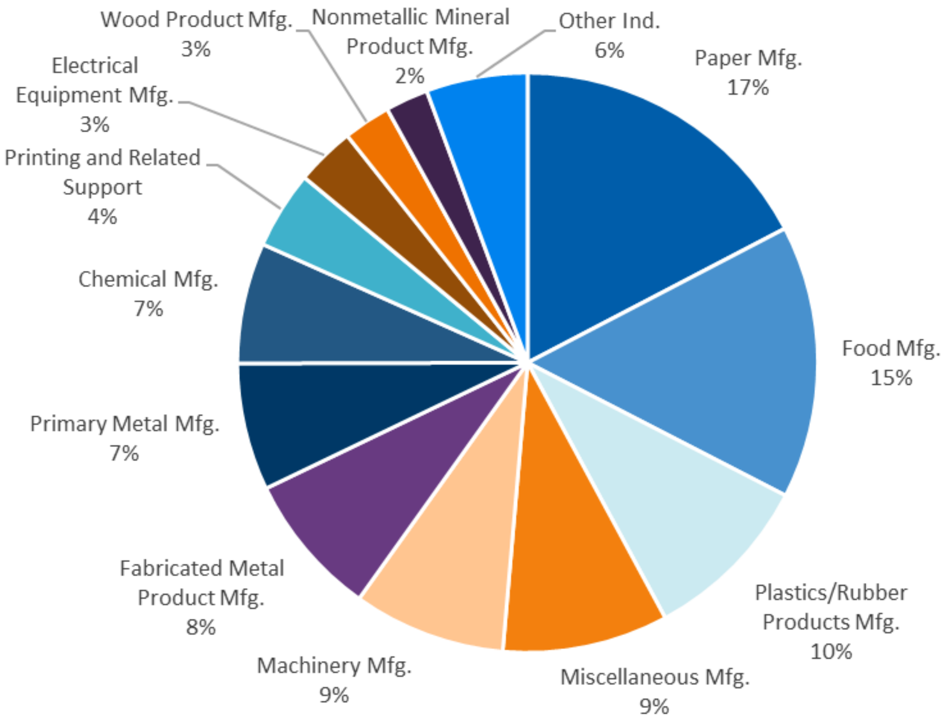
As shown in Table 21, the assessment identified nearly 3,727 GWh of cumulative technical potential within the industrial sector, with 88% (3,274 GWh) of the technical potential determined to be economically feasible. Within the industrial sector overall, technical potential accounted for approximately 15% of forecasted 2030 baseline sales, while economic potential accounted for roughly 13%.

Table 21. Industrial Technical and Economic Electric Energy Efficiency Potential by Segment

Segment	2030 Forecast Sales (MWh)	12-year Technical Potential (MWh)	Technical Potential Percentage of Sales	12-year Economic Potential (MWh)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Paper Mfg.	4,828,947	605,395	13%	567,688	12%	94%
Food Mfg.	3,840,869	596,028	16%	498,749	13%	84%
Plastics/Rubber Products Mfg.	2,114,401	352,558	17%	312,901	15%	89%
Miscellaneous Mfg.	2,003,452	375,797	19%	302,418	15%	80%
Machinery Mfg.	1,767,767	330,273	19%	277,928	16%	84%
Fabricated Metal Product Mfg.	1,706,519	288,056	17%	261,952	15%	91%
Primary Metal Mfg.	2,681,133	245,693	9%	232,330	9%	95%
Chemical Mfg.	1,570,024	240,829	15%	220,588	14%	92%
Printing and Related Support	1,014,102	177,873	18%	141,798	14%	80%
Electrical Equipment Mfg.	708,237	124,177	18%	107,652	15%	87%
Wood Product Mfg.	550,458	92,208	17%	86,371	16%	94%
Nonmetallic Mineral Product Mfg.	555,807	82,539	15%	78,146	14%	95%
Transportation Equipment Mfg.	443,912	87,429	20%	76,117	17%	87%
Street Lighting	63,399	33,473	53%	33,473	53%	100%
Wastewater Treatment	419,856	46,768	11%	30,575	7%	65%
Mining	211,375	21,717	10%	21,717	10%	100%
Furniture Mfg.	128,245	23,601	18%	20,222	16%	86%
Water	337,487	2,907	1%	2,907	1%	100%
Total	**24,945,991**	**3,727,323**	**15%**	**3,273,532**	**13%**	**88%**

Paper (17%), food (15%), plastics and rubber products (10%), and miscellaneous manufacturing (9%) together accounted for the majority (51%) of electric industrial cumulative economic savings potential, as shown in Figure 18.

Figure 18. Industrial Electric Economic Energy Efficiency Potential by Segment



The "All Other Industries" segment shown in Figure 18 accounted for 6% of the sector's electric economic potential and included the following segments:

- Transportation equipment manufacturing
- Street lighting
- Wastewater treatment
- Mining
- Furniture manufacturing
- Water

As shown in Table 22, the assessment identified 78 million therms of technical natural gas potential within the industrial sector, with all 78 million therms determined as economically feasible. Within the industrial sector overall, cumulative technical and economic potential both accounted for approximately 30% of forecasted 2030 baseline sales.

Table 22. Industrial Technical and Economic Natural Gas Energy Efficiency Potential by Segment

Segment	2030 Forecast Sales (Thousand Therms)	12-year Technical Potential (Thousand Therms)	Technical Potential Percentage of Sales	12-year Economic Potential (Thousand Therms)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Food Mfg.	63,946	22,799	36%	22,799	36%	100%
Paper Mfg.	48,536	16,120	33%	16,120	33%	100%
Miscellaneous Mfg.	30,528	9,809	32%	9,809	32%	100%
Chemical Mfg.	29,330	8,628	29%	8,628	29%	100%
Fabricated Metal Product Mfg.	17,692	5,026	28%	5,026	28%	100%
Primary Metal Mfg.	22,758	5,009	22%	5,009	22%	100%
Machinery Mfg.	13,698	3,138	23%	3,138	23%	100%
Electrical Equipment Mfg.	6,468	1,689	26%	1,689	26%	100%
Printing and Related Support	6,498	1,475	23%	1,475	23%	100%
Nonmetallic Mineral Product Mfg.	8,218	1,420	17%	1,420	17%	100%
Plastics/Rubber Products Mfg.	5,212	1,405	27%	1,405	27%	100%
Transportation Equipment Mfg.	4,215	1,029	24%	1,029	24%	100%
Wood Product Mfg.	3,153	680	22%	680	22%	100%
Furniture Mfg.	957	188	20%	188	20%	100%
Total	**261,208**	**78,415**	**30%**	**78,415**	**30%**	**100%**

Food (29%), paper (21%), miscellaneous (13%), chemical (11%), and fabricated metal (6%) accounted for the majority (80%) of natural gas industrial cumulative economic savings potential, as shown in Figure 19.

Figure 19. Industrial Natural Gas Economic Energy Efficiency Potential by Segment

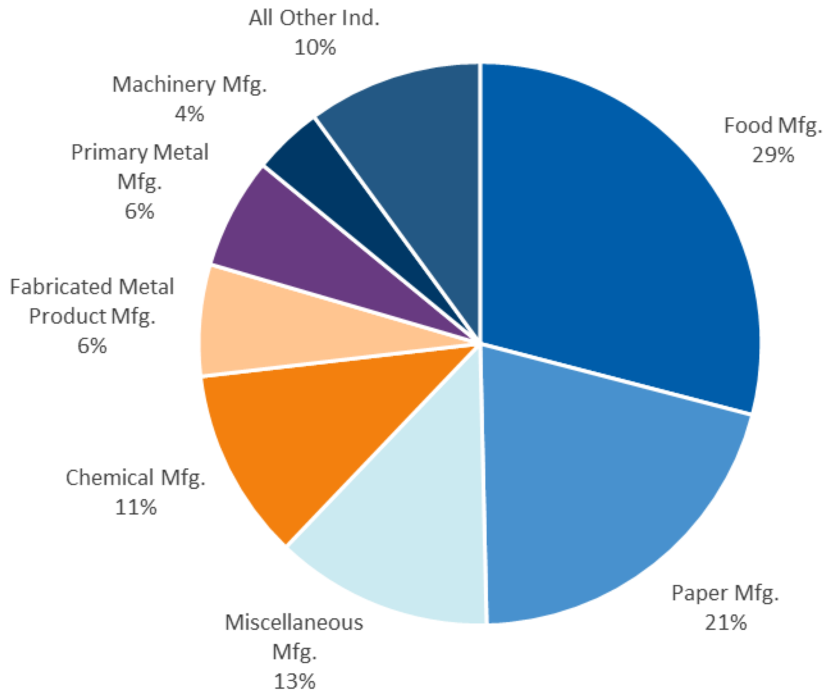


Table 23 shows 12-year potential by electric industrial end use, and Figure 20 shows the distribution of industrial economic potential by end use. The process end use accounted for 34% and 36% of technical and economic industrial electric savings potential, respectively. While the process end use economic potential accounts for the largest end use category in terms of savings, characterizing process improvements may be underestimated because they are often specialized custom improvements and difficult to estimate across an entire industry.

As a result, this study may not reflect the total program potential because of Focus on Energy's experience of developing process measures for specific industrial applications. For example, Focus on Energy's recent electric savings from its most customized process measures average 30.8 million kWh per year. Assuming this level of savings achievement continues throughout the study period, this could result in 370 million kWh in additional potential.

Table 23. Industrial Electric Technical and Economic Energy Efficiency Potential by End Use

End Use	2030 Forecast Sales (MWh)	12-year Technical Potential (MWh)	Technical Potential Percentage of Sales	12-year Economic Potential (MWh)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Process	9,286,204	1,267,626	14%	1,170,152	13%	92%
HVAC	2,548,488	693,984	27%	353,859	14%	51%
Lighting	1,995,265	629,144	32%	629,144	32%	100%
Motors Other	4,811,720	576,306	12%	576,306	12%	100%
Pumps	2,857,467	317,326	11%	317,326	11%	100%
Fans	1,753,380	179,076	10%	179,076	10%	100%
Other	1,395,222	46,406	3%	30,214	2%	65%
Indirect Boiler	298,245	17,455	6%	17,455	6%	100%
Total	**24,945,991**	**3,727,323**	**15%**	**3,273,532**	**13%**	**88%**

Figure 20. Industrial Electric Economic Energy Efficiency Potential by End Use

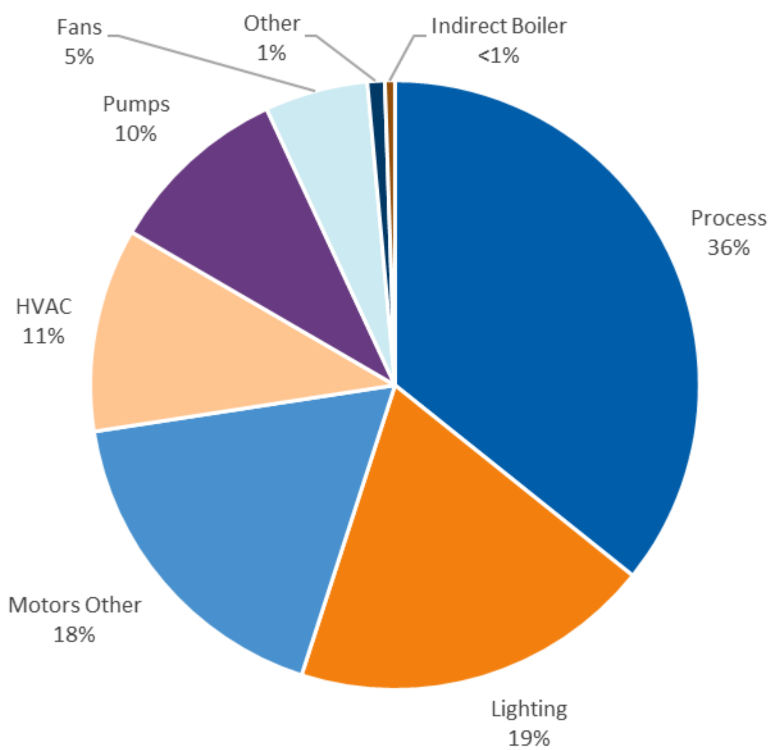


Table 24 shows 12-year potential by industrial natural gas end use, and Figure 21 shows the distribution of industrial economic potential by end use. Indirect boiler end use accounted for 64% of technical and economic industrial natural gas savings potential, followed by process (28%) and HVAC (8%). As mentioned above, not all program potential may be captured in the process end-use economic potential. For example, Focus on Energy's recent natural gas savings from its most customized process measures average 4.7 million therms per year. Assuming this level of savings achievement continues throughout the study period, this could result in 56 million therms in additional potential.

Table 24. Industrial Natural Gas Technical and Economic Energy Efficiency Potential by End Use

End Use	2030 Forecast Sales (Thousand Therms)	12-year Technical Potential (Thousand Therms)	Technical Potential Percentage of Sales	12-year Economic Potential (Thousand Therms)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Indirect Boiler	118,051	50,186	43%	50,186	43%	100%
Process	114,700	22,054	19%	22,054	19%	100%
HVAC	28,456	6,175	22%	6,175	22%	100%
Total	**261,208**	**78,415**	**30%**	**78,415**	**30%**	**100%**

Figure 21. Industrial Natural Gas Economic Energy Efficiency Potential by End Use

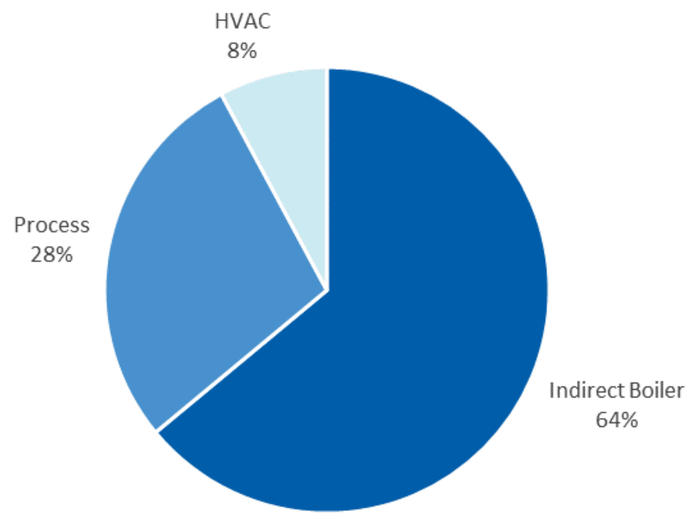


Table 25 shows the top 15 electric energy-saving industrial measures. Collectively, these 15 measures represented 60% of the sector's total economic potential. Linear LED lighting packages alone accounted for almost 13% of the industrial electric economic savings potential.

Table 25. Top Industrial Electric Energy Efficiency Measures

Industrial Energy Efficiency Measure	12-Year Economic Potential (MWh)	Percentage of Total Industrial Potential
Lighting - Linear LED Packages	419,638	12.8%
Cooling Tower Operation and Maintenance	154,446	4.7%
Thermal Systems Recover Heat and Use for Preheating, Space Heating, Power Generation, Steam Generation, Transformers, Exhausts, Engines, Compressors, Dryers, Waste Process Heat, etc.	137,920	4.2%
Enhanced (Ultra-PE) Motor 1-15 HP, 1200-3600 Rpm	135,735	4.1%
Optimize Chiller and Refrigeration Systems	128,655	3.9%
Optimize Motor Systems with Right Sizing	123,711	3.8%
Optimize Pump Systems	113,902	3.5%
Install Adjustable Frequency Drive for Variable Pump, Blower, and Compressor Loads	104,406	3.2%
Thermal Systems Add Insulation to Equipment	104,163	3.2%
Equipment Upgrade - Air Compressor	102,039	3.1%
Install Compressor Controls	90,048	2.8%
Eliminate or Reduce Compressed Air Used for Cooling, Agitating Liquids, Moving Product, Or Drying	88,545	2.7%
Lighting - Lamp (Screw Base) LED	87,635	2.7%
Install Adjustable Frequency Drive for Variable Pump Loads	81,351	2.5%
Building Envelope Infiltration, Insulation, And Duct System Improvements	81,284	2.5%

Table 26 shows the top 15 natural gas energy-saving industrial measures. Collectively, these 15 measures represented approximately 95% of the sector's total economic potential. Waste heat from hot flue gases to preheat accounted for almost 11% of the industrial natural gas economic savings potential. As previously noted, these measure results in this study do not fully capture process-related savings. While this study included process improvements related to specific technologies and end uses (e.g., heat recovery, process cooling), the study did not include less defined process improvements as they were difficult to characterize in terms of energy savings and costs. As a result, the study may underrepresent natural gas potential savings for certain segments, particularly given Focus on Energy's history of deriving substantial savings from custom process measures.

Table 26. Top Industrial Natural Gas Energy Efficiency Measures

Industrial Energy Efficiency Measure	12-Year Economic Potential (Thousand Therms)	Percentage of Total Industrial Potential
Waste Heat from Hot Flue Gases to Preheat	8,444	10.8%
Heat Recovery and Waste Heat for Process	7,468	9.5%
Equipment Upgrade - Boiler Replacement	7,354	9.4%
Install or Repair Insulation on Condensate Lines and Optimize Condensate	6,985	8.9%
Improve Combustion Control Capability and Air Flow	6,715	8.6%
Optimize Heating System to Improve Burner Efficiency, Reduce Energy Requirements and Heat Treatment Process	6,621	8.4%
Analyze Flue Gas for Proper Air/Fuel Ratio	5,880	7.5%
Isolate and Prevent Infiltration of Heat Loss from Equipment	4,995	6.4%
Boiler - Operation, Maintenance, and Scheduling	4,563	5.8%
Repair or Replace Steam Traps	4,462	5.7%
Insulate Steam, Hot Water Lines or Feedwater Tank	3,510	4.5%
Repair and Eliminate Steam Leaks	3,240	4.1%
Optimize Ventilation System	1,410	1.8%
HVAC Equipment Scheduling Improvements - HVAC Controls, Timers or Thermostats	1,352	1.7%
Building Envelope Insulation Improvements	1,281	1.6%

Agricultural

Cadmus identified agricultural specific measures for three segments (dairy, irrigation, and miscellaneous agriculture), but not all applicable commercial or government measures (e.g., HVAC measures) were included as part the agricultural assessment of potential. As a result, not all Focus on Energy program measures may be presented here and may show lower estimates of potential compared to programs serving agricultural customers.

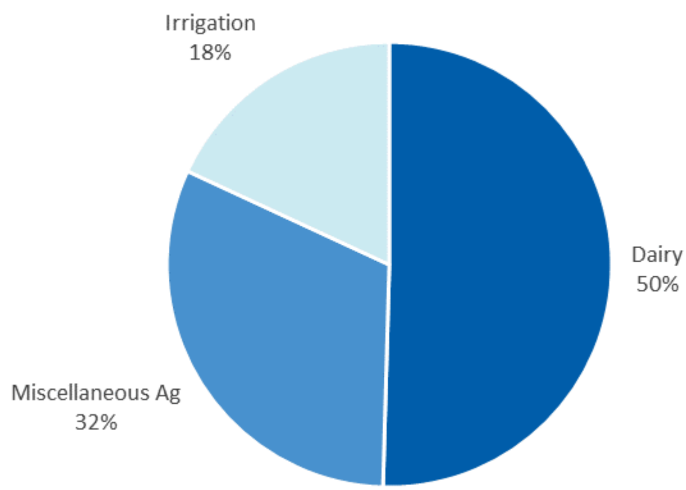
Cadmus estimated agricultural potential of the three segments listed in Table 27, based on allocations from Focus on Energy participating utilities' nonresidential customer databases. Table 27 table also summarizes baseline 2030 forecast sales, cumulative technical and economic potential, and those potentials as a percentage of baseline 2030 forecast sales.

Table 27. Agricultural Electric Technical and Economic Energy Efficiency Potential by Segment

Segment	2030 Forecast Sales (MWh)	12-year Technical Potential (MWh)	Technical Potential Percentage of Sales	12-year Economic Potential (MWh)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Dairy	905,534	253,530	28%	253,530	28%	100%
Miscellaneous Ag	1,190,602	158,073	13%	158,073	13%	100%
Irrigation	385,018	100,463	26%	90,908	24%	90%
Total	**2,481,154**	**512,065**	**21%**	**502,510**	**20%**	**98%**

Overall, 98% of the agricultural electric technical potential was cost-effective. The dairy segment accounted for about one-half of the agricultural electric economic potential, followed by miscellaneous agriculture(32%) and irrigation (18%), as shown Figure 22.[7]

Figure 22. Agricultural Electric Economic Energy Efficiency Potential by Segment



Cadmus estimated agricultural natural gas potential for the two segments listed in Table 28, based on allocations from Focus on Energy participating utilities' nonresidential customer databases. Table 28 also summarizes baseline 2030 forecast sales, cumulative technical and economic potential, and those potentials as a percentage of baseline 2030 forecast sales. Figure 23 shows economic potential by segment.

[7] Miscellaneous agriculture represents all non-dairy or irrigation farms, such as dry cows, hog, poultry, green houses, and other agriculture.

Table 28. Agricultural Natural Gas Technical and Economic Energy Efficiency Potential by Segment

Segment	2030 Forecast Sales (Thousand Therms)	12-year Technical Potential (Thousand Therms)	Technical Potential Percentage of Sales	12-year Economic Potential (Thousand Therms)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Dairy	1,997	309	15%	151	8%	49%
Miscellaneous Ag	7,002	1,164	17%	22	0%	2%
Total	**8,999**	**1,473**	**16%**	**173**	**2%**	**12%**

Figure 23. Agricultural Natural Gas Economic Energy Efficiency Potential by Segment

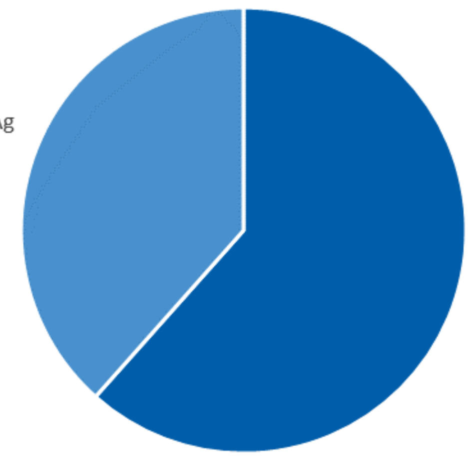


Table 29 shows 12-year cumulative potential by agricultural electric end use, and Figure 24 shows the distribution of agricultural electric economic potential by end use. Pumps (29%), ventilation (28%), and lighting (26%) together accounted for approximately 83% of the agricultural electric economic potential.

Table 29. Agricultural Electric Technical and Economic Potential by End Use

End Use	2030 Forecast Sales (MWh)	12-year Technical Potential (MWh)	Technical Potential Percentage of Sales	12-year Economic Potential (MWh)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Pumps	961,430	154,205	16%	144,649	15%	94%
Ventilation	660,096	141,119	21%	141,119	21%	100%
Lighting	332,548	131,613	40%	131,613	40%	100%
Water Heat	74,628	36,328	49%	36,328	49%	100%
Process	226,383	35,639	16%	35,639	16%	100%
Other	226,069	13,161	6%	13,161	6%	100%
Total	**2,481,154**	**512,065**	**21%**	**502,510**	**20%**	**98%**

Figure 24. Agricultural Electric Economic Potential by End Use

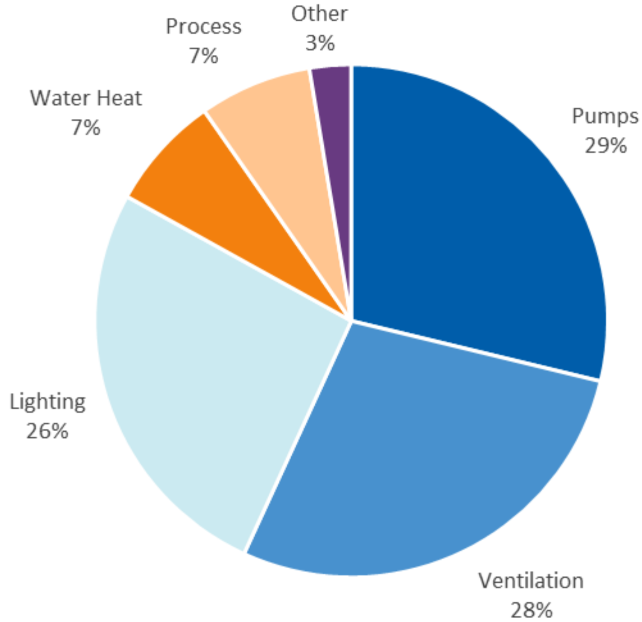


Table 30 shows 12-year cumulative potential by gas agriculture end use.

Table 30. Agricultural Natural Gas Technical and Economic Potential by End Use

End Use	2030 Forecast Sales (Thousand Therms)	12-year Technical Potential (Thousand Therms)	Technical Potential Percentage of Sales	12-year Economic Potential (Thousand Therms)	Economic Potential Percentage of Sales	Economic Potential Percentage of Technical
Gas	8,999	1,473	16%	173	2%	12%
Total	**8,999**	**1,473**	**16%**	**173**	**2%**	**12%**

Table 31 shows the top energy-saving electric agricultural measures. Collectively, these 15 measures represented approximately 95% of the sector’s total economic potential. VFD installations on ventilation and circulation fans (11.6%) and high-volume, low-speed fans (10.6%) are the top two saving electric agriculture measures.

Table 31. Top Agriculture Electric Energy Efficiency Measures

Agriculture Energy Efficiency Measure	12-Year Cumulative Economic Potential (MWh)	Percentage of Total Agriculture Potential
VFD, Ventilation/Circulation Fan	58,238	11.6%
High-Volume Low-Speed (HVLS) Fan	53,402	10.6%
Lighting - High Bay LED Packages	43,366	8.6%
Low Energy Spray Application	41,251	8.2%
Lighting - Lamp (Screw Base) LED	38,639	7.7%

Agriculture Energy Efficiency Measure	12-Year Cumulative Economic Potential (MWh)	Percentage of Total Agriculture Potential
VFD for Agriculture Process Pump, Constant Torque, or Irrigation Well Pump	36,381	7.2%
Water Heater Electric Upgrade	31,935	6.4%
Ventilation/Exhaust Fan	26,890	5.4%
Lighting Controls - Occupancy Sensors, Photocell Controls, And Timers	25,397	5.1%
VFD, Agriculture Primary and Secondary Use Water System	24,858	4.9%
Lighting - Linear LED Packages	24,211	4.8%
Variable Speed Control Vacuum Pump (Dairy Farm, Parlor, Milk House)	23,373	4.7%
Plate Heat Exchanger and Well Water Pre-Cooler (Dairy Farm, Parlor, Milk House)	23,086	4.6%
Irrigation Pressure Reduction	17,808	3.5%
Scroll Compressor Replacement (Dairy Farm, Parlor, Milk House)	10,761	2.1%

Table 32 shows the top energy-saving natural gas agricultural measures. Collectively, these four measures represented 100% of the economic natural gas savings.

Table 32. Top Agriculture Natural Gas Energy Efficiency Measures

Agriculture Energy Efficiency Measure	12-Year Cumulative Economic Potential (Thousand Therms)	Percentage of Total Agriculture Potential
Refrigeration Heat Recovery Unit (Gas)	151	87.1%
Thermal Curtain (Natural Gas Only)	18	10.3%
Greenhouse Unit Heater (Natural Gas Only), >= 90% thermal efficiency, per input MBh, for retrofit	4	2.6%
Double Polyethylene Treated Film	<1	<0.1%

In addition to the measures listed in Table 32, the two measures with the highest natural gas technical potential savings—gas water heater upgrade (858 thousand therms) and efficient natural gas drain dryer (425 thousand therms)—were not cost-effective.

Achievable Potential

This study defines "achievable potential" as the portion of economic potential that customers would be willing to adopt if the financial barriers to purchasing energy efficiency measures could be reduced through incentives, marketing, and education. Therefore, Cadmus measures and expresses achievable potential as a fraction (percentage) of economic potential. Although estimating technical and economic potentials fundamentally remains an engineering and accounting endeavor, based on industry-standard practices and methodologies, achievable potential proves difficult to quantify and reliably predict as it depends on a large number of behavioral factors that, over time, tend to change unpredictably.

A number of factors account for the gap between economic and achievable potential, including customer awareness, perceptions of energy efficiency's value, and energy efficiency measures' upfront costs. For new measures and programs, additional practical constraints regarding the availability of delivery infrastructure must be considered. Energy efficiency literature documents these barriers extensively.[8]

Focus on Energy can mitigate some of these market barriers through program designs and delivery processes, but resolving other market barriers remains out of reach. For example, Focus of Energy can reduce first-cost barriers by providing financial incentives to lower upfront costs and to improve customer paybacks. However, because Focus on Energy incentives only cover a portion of most measures' incremental costs, incentives may prove insufficient to motivate some customers to adopt energy efficiency measures. This particularly holds true for the commercial sector and for mechanical equipment in the residential sector, where upfront costs tend to be high.

Thus, evaluating achievable potential depends on assessing two questions:

- Which barriers can a household or business overcome over the course of the planning horizon?
- How much economic potential can be deemed reasonably achievable?

Willingness-to-Adopt Efficiency Measures

To assess the fraction of customers likely to adopt an energy efficiency measure, the phone surveys included a battery of questions to elicit information about customers' willingness to adopt measures under different *hypothetical* incentive scenarios. For several measure types (e.g., appliances, heating and cooling equipment, lighting, weatherization, etc.), survey respondents were first asked if they would adopt an efficient measure if Focus on Energy covered 25% of the measure's incremental cost (i.e., the cost to upgrade) corresponding to the total low incentive achievable scenario.

Cadmus then asked whether the customer would adopt the efficient measure if Focus on Energy covered 50% of the incremental costs corresponding to the total moderate incentive achievable

8 William H. Golove and Joseph H. Eto, "Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency," LBL-38059 UC-1322, March 1996.

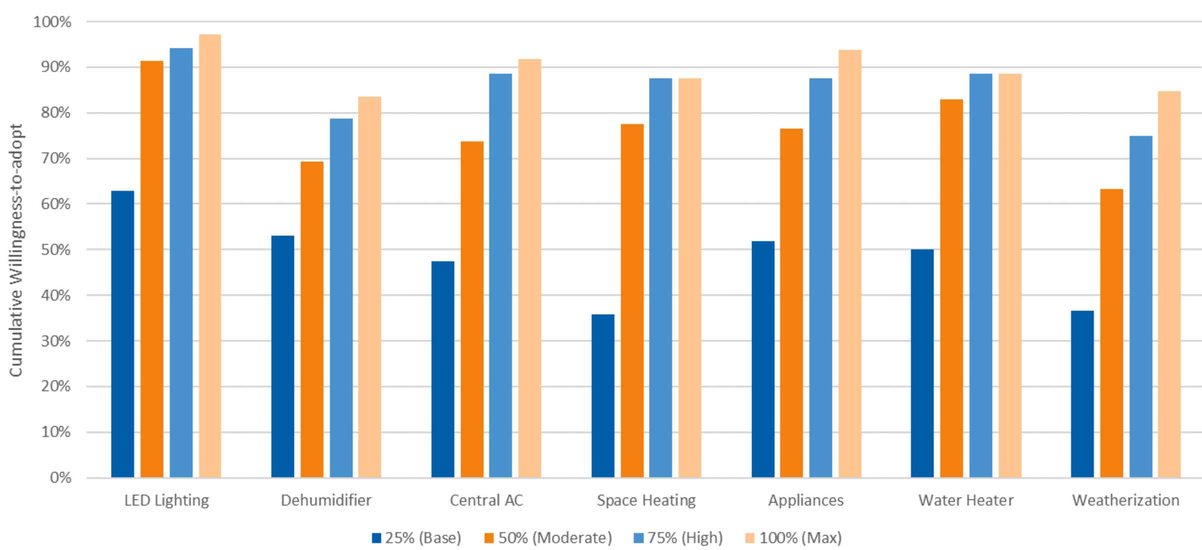
scenario. The surveys also asked if customers would adopt efficient measures if Focus on Energy covered 75% of the measure's incremental costs corresponding to the total high incentive achievable scenario. Finally, the survey asked if a customer would adopt the efficient measure at the maximum incentive 100% payment level, making it free for the customer.

Table 33 summarizes assumptions for each achievable scenario. Figure 25 shows a sample of the results from one sector (residential) of customer's willingness to adopt efficient measures under the different incentive scenarios. The willingness to adopt results from of the sectors can be found in Appendix D.

Table 33. Achievable Potential Scenarios

Scenario	Incentive
Low Incentive	25%
Moderate Incentive	50%
High Incentive	75%
Max Incentive	100%

Figure 25. Residential Customers' Willingness to Adopt by Measure Type



Ramp Rates

Cadmus developed a series of ramp rates to determine the incremental, year-to-year achievable potential for this study and applied one ramp rate to each energy efficiency measure within the study. Ramp rates are not sector specific; rather, they are generalized s-curves that assume an initial saturation rate in the study's first year (2019) before progressing to 100% on either an incremental or cumulative basis, depending on the resource.

To determine which ramp rate should be applied for a given measure, Cadmus developed the following hierarchy:

1. For measures that Focus on Energy has already offered and achieved moderate-to-high energy-savings levels, Cadmus applied more aggressive ramp rates.
2. For measures with relatively low, no, or negative incremental costs, Cadmus applied more aggressive ramp rates.
3. For measures that Focus on Energy has not offered or that have achieved less-than-moderate levels of energy savings, Cadmus applied more conservative ramp rates.

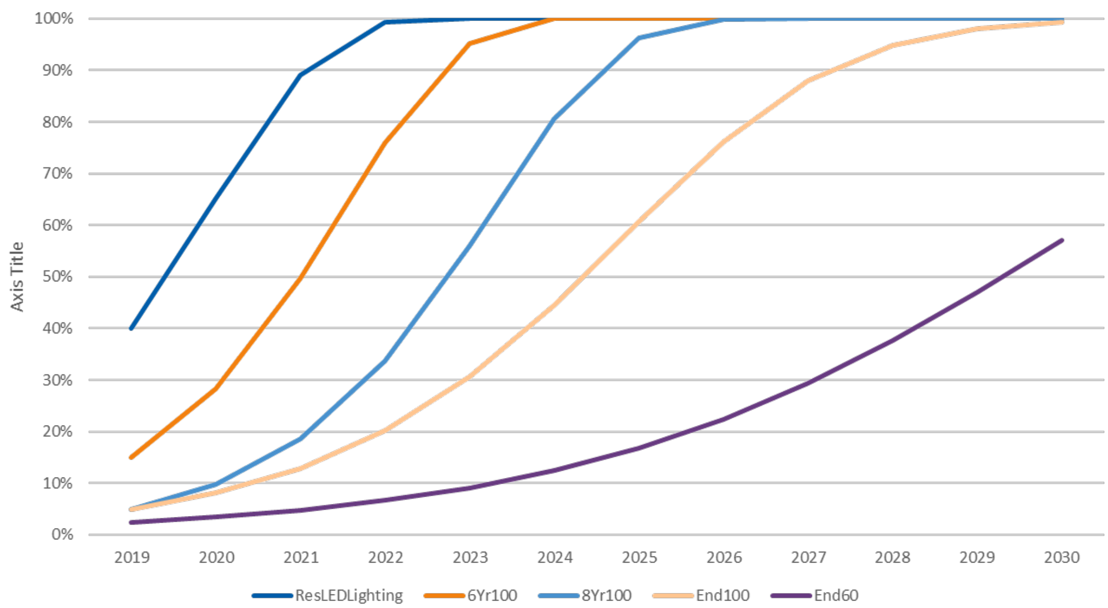
Table 34 provides the 10 ramp rate names applied to measures in this study to determine the achievable potential. For modeling purposes, separate ramp rates were established for retrofits and lost opportunities, but those separate ramp rates were assigned similar names and meanings. The table lists ramp rate names in each category (i.e., discretionary and nondiscretionary), from most to least aggressive.

Table 34. Discretionary and Nondiscretionary Ramp Rate Names

Discretionary (Retrofit)	Nondiscretionary (Lost Opportunity)
Retro - ResLEDLighting	ResLEDLighting
Retro - 6Yr100	6Yr100
Retro - 8Yr100	8Yr100
Retro - End100	End100
Retro - End60	End60

Figure 26, which depicts the ramp rates, shows the discretionary values on a cumulative basis. As these resources were available at the study's beginning and can be acquired at any time, the first-year values represent the percentage of total retrofits acquired in that year. A retrofit measure assigned the "6Yr100 – Retro" ramp rate will have reached 100% saturation in the study's sixth year, whereas a retrofit measure assigned the "End100" ramp rate will not reach 100% saturation until the last year of the study. Residential LEDs were assigned a more aggressive ramp rate of their own due to (1) a relatively high rate of saturation, (2) recent program success with these products, (3) their rapidly declining prices, and (4) the expectation that the Energy Independence and Security Act of 2007 (EISA) backstop in 2020—requiring all general service lamps and most specialty lamps meet a minimum federal standard of 45 lumens per watt—will reduce the available technical, economic, and achievable potential after that point in the study.

Figure 26. Potential Study Ramp Rates



From the standpoint of nondiscretionary measures, the percentage values in each year represent the percentage of economic units that are achievable for that year. For example, in 2023, the “6Yr100” ramp rate assumed that 95% of the economic units that are available that year are achievable, whereas the “8Yr100” and “End100” rates assumed 56% and 31%, respectively.

Achievable Potential

Cadmus calculated BAU achievable energy efficiency potential by multiplying economic potential by the percentage of customers’ willingness to adopt an efficiency measure (for each measure type and incentive scenario shown in Figure 25), and by spreading discretionary and lost opportunity savings over the study horizon using a ramp rate selection based on Focus on Energy’s recent, measure-level energy efficiency program achievements.

Table 35 presents the 12-year cumulative electric achievable energy efficiency potential for each scenario (i.e., BAU, total low incentive, total moderate incentive, total high incentive, and total maximum incentive) and for the 2030 Focus on Energy participating utilities’ forecasted sales in megawatt hours. BAU achievable potential, as shown in the following tables and figures, represents the 25% incentive level most similar to Focus on Energy’s current incentive level and as constrained by the $100 million statutory funding cap. Available achievable potential ranges from 9.1% of the total 2030 forecasted load in the BAU scenario to 14.2% in the maximum incentive scenario, which corresponds to annual savings as percentage of sales of 0.80% to 1.29%.

Table 35. 12-Year Electric Achievable Potential by Scenario—Energy

Sector[1]	2030 Forecast Sales (MWh)	BAU Achievable Potential (MWh)	Total Low Incentive Achievable Potential (MWh)	Total Moderate Incentive Achievable Potential (MWh)	Total High Incentive Achievable Potential (MWh)	Total Maximum Incentive Achievable Potential (MWh)
Single-Family	17,348,706	11.7%	11.9%	17.1%	17.9%	18.5%
Multifamily	2,304,239	10.0%	10.2%	14.7%	15.5%	16.1%
Commercial	18,005,901	8.5%	8.8%	12.1%	13.1%	13.7%
Government	3,106,013	10.5%	11.0%	13.6%	14.4%	14.7%
Industrial	24,945,991	7.4%	7.4%	9.7%	10.8%	11.2%
Agricultural[2]	2,481,154	9.3%	9.3%	13.9%	15.4%	16.0%
Total	**68,192,004**	**9.1%**	**9.3%**	**12.7%**	**13.7%**	**14.2%**

[1] Table values are reported at the site and not at the generator (e.g., values presented do not include line losses).
[2] Modeled potential includes agriculture-specific measures. Agricultural program potential may be higher when accounting for general-use electric measures classified in other nonresidential sectors.

Table 36 presents the 12-year cumulative natural gas achievable energy efficiency potential for each scenario (i.e., BAU, total low incentive, total moderate incentive, total high incentive, and total maximum incentive) and for the 2030 Focus on Energy participating utilities' forecasted sales in thousands of therms. Available achievable potential ranges from 11.0% of the total 2030 forecasted load in the BAU achievable scenario to 18.3% in the maximum incentive achievable potential scenario, corresponding to annual savings as percentage of forecasted natural gas sales from 0.98% to 1.70%.

Table 36. 12-Year Natural Gas Achievable Potential by Scenario

Sector[1]	2030 Forecast Sales (Thousand Therms)	BAU Achievable Potential (Thousand Therms)	Total Low Incentive Achievable Potential (Thousand Therms)	Total Moderate Incentive Achievable Potential (Thousand Therms)	Total High Incentive Achievable Potential (Thousand Therms)	Total Maximum Incentive Achievable Potential (Thousand Therms)
Single-Family	1,292,521	8.4%	8.4%	12.8%	13.6%	14.2%
Multifamily	201,299	7.2%	7.2%	11.1%	12.4%	13.5%
Commercial	560,463	13.5%	13.5%	18.8%	21.1%	22.5%
Government	135,460	21.6%	21.6%	28.8%	32.0%	33.1%
Industrial	261,208	16.2%	16.2%	21.6%	24.3%	26.1%
Agricultural[2]	8,999	0.8%	0.8%	1.3%	1.6%	1.8%
Total	**2,459,950**	**11.0%**	**11.0%**	**15.8%**	**17.3%**	**18.3%**

[1] Table values are reported at the site and not at the generator (e.g., values presented do not include line losses).
[2] Modeled potential includes agriculture-specific measures. Agricultural program potential may be higher when accounting for general-use electric measures classified in other nonresidential sectors.

Scenario Analysis

In addition to BAU achievable potential, Cadmus developed 11 study-wide potential scenarios. These scenarios changed various assumptions, including a sensitivity analysis on key inputs such as discount rates, carbon values, cost-effectiveness test design, and minimum MTRC thresholds for determining cost-effectiveness. Because these cost-effectiveness assumptions directly impact economic potential, results below are presented relative to the base economic potential. The scenarios would have a similar percentage impact on each total achievable potential scenario, but minimal impact on BAU achievable potential due to the funding cap in that scenario. The following list defines the scenarios, their assumptions, and high-level results. Full details and results of these scenarios can be found in Appendix D.

- **Carbon value scenarios:** The BAU scenario uses a $15 carbon per ton value. Cadmus conducted a sensitivity analysis of three additional carbon values ($0, $30, and $50):
  - **$0/ton**. Total electric and natural gas economic potential decreased by 2.5% and 0.8%, respectively, compared with the base economic potential.
  - **$30/ton**. Total electric and natural gas economic potential increased by 2.5% and 1%, respectively, compared with the base economic potential.
  - **$50/ton**. Total electric and natural gas economic potential increased by 6.8% and 4.1%, respectively, compared with the base economic potential.
- **Discount rate scenarios:** The base economic potential assumes a 2% discount rate. A sensitivity analysis of the discount rate examines an upper and lower bound (0% and 5%).

    - **0% discount rate.** Findings indicate the upper bound (0%) increases electric and gas economic potential by 6.4% and 8.0%, respectively.
    - **5% discount rate.** The lower bound (5%) decreases electric and gas economic potential by 4.9% and 6.0%, respectively.
- **Cost test scenarios:** The base economic potential assesses the cost-effectiveness for each measure using Focus on Energy's MTRC. In this cost test scenario analysis, Cadmus assessed potential by screening measures using the Utility Cost Test (UCT) and Societal Cost Test (SCT).
    - **SCT cost test.** Screening measures using the SCT slightly increased the economic potential, mainly due to the addition of a 10% conservation benefits adder. The SCT cost scenario increases the electric and gas economic potential by 2.6% and 5.0%, respectively.
    - **UCT cost test.** Screening measures using UCT increased the potential more than using the SCT. Overall, the electric economic potential increases by 9.3% compared with the base economic potential scenario. The economic natural gas potential increases by approximately 41% compared with the base economic potential scenario.
- **Combined effects scenarios:** These scenarios arise as the net result of different, simultaneous inputs to represent an upper bound of economic potential. The two scenarios are defined primarily by the choice of cost-effectiveness test employed—either the SCT or UCT—and by the choice of values for additional variables.
    - Screening measures using the SCT, with the following inputs:
        - 10% conservation benefits adder
        - Carbon value of $50 per ton
        - 0% discount rate
        - The SCT combined effects scenario offers an electric economic potential 1,248,684 MWh (8.7%) higher than the base economic potential and an economic natural gas potential 72.9 million therms (14.5%) higher than the base natural gas economic potential.
    - Screening the measures using the UCT, with the following inputs:
        - 0% discount rate
        - The UCT combined effects scenario offer an electric economic potential 2,076,488 MWh (14.5%) higher than the base economic potential and an economic natural gas potential 208 million therms (41.4%) higher than the base natural gas economic potential.
- **Minimum MTRC threshold scenarios:** These scenarios test the sensitivity of economic potential using two separate MTRC thresholds. Such models reflect that non-cost-effective measures may be included in Focus on Energy programs that meet the program requirement to maintain cost-effective residential and nonresidential portfolios. Despite including measures in these scenarios with MTRC BCRs less than 1.0, the overall economic potential in the residential and non-

residential sectors would likely still remain cost-effective in both of these scenarios. These thresholds include the following:

  - **0.75 MTRC threshold.** Screening measures for economic potential using an MTRC greater than or equal to 0.75 increases total economic electric and natural gas potential by 7.4% and 17.9%, respectively. The economic electric and natural gas potential under this scenario equates to average annual savings of 2.1% and 2.3% of forecasted sales, respectively.
  - **0.50 MTRC threshold.** Screening measures for economic potential using an MTRC greater than or equal to 0.50 increases total economic electric and natural gas potential by 20.7% and 37.3%, respectively. The economic electric and natural gas potential under this scenario equates to average annual savings of 2.3% and 2.8% of forecasted sales, respectively.

- **Budget scenarios:** This scenario analysis looks at budget implications at different incentives levels as well as at results of modified TRC benefit-cost analysis for each achievable potential scenario, first examining high-level budget estimates for the BAU, moderate 50% incentive, high 75% incentive, maximum 100% incentive, and combined effects achievable potential scenarios. This section also presents the results of modified TRC benefit-cost analysis for each achievable potential scenario and a comparison of the BAU achievable potential modified TRC to the modified TRC values resulting from the 0% and 5% discount rate scenarios.
  - BAU represents the $90 million budget cap (without renewables). If incentives made up 50% of the measure equipment incremental cost, the budget would increase to almost $205 million. Incentives at 100% would increase the budget to $426 million.
  - The modified TRC values remain relatively consistent for the four-year achievable estimates, ranging from 10.57 to 10.74, depending upon the scenario.

In addition to the cost-effectiveness scenarios above, Cadmus conducted additional scenarios to illustrate the effects of study assumptions related to residential lighting baselines, naturally occurring potential, and building energy codes.

- **Residential lighting scenarios:** EISA includes a backstop provision that requires even higher-efficiency technologies, beginning in 2020 (i.e., 45 lumens per watt or better). Because of pending legal challenges, uncertainty remains regarding how this standard will be implemented. For the BAU, Cadmus assumed standard and specialty lamps would be impacted by the EISA backstop provision in 2020, and thus used a 45 lumen per watt lighting baseline, starting in 2020. Two residential lighting scenarios were evaluated:
  - **Alterative Scenario 1.** Specialty bulbs are not impacted by the EISA backstop provision.
  - **Alterative Scenario 2.** Backstop implementation does not take place in 2020; instead, LEDs effectively become the baseline starting in 2023 for standard bulbs and 2025 for specialty bulbs.
    - Overall 12-year technical (2.4%), economic (1.7%), and achievable (3.6%) potential increased slightly between the base and first alternate scenarios.

- In the second alternate scenario, technical potential increased by 0.2% relative to the base scenario, while economic and achievable potentials decreased by 0.7% and 2%, respectively.

- **Naturally occurring potential impacts:** This refers to reductions in energy use occurring due to normal market forces that are considered "involuntary" measures (e.g., adoption of codes and standards). The potential study results excluded naturally occurring impacts. This scenario presents the magnitude of these "involuntary" impacts. This analysis did not attempt to predict how federal standards might change in the future.
  - Total electric cumulative non-programmatic savings from federal standards and natural adoption of energy efficiency technologies through 2030 equaled 6,781,850 MWh. Single-family and multifamily sectors accounted for over 5,412,456 MWh (80%), and the commercial and government sectors accounted for the remaining 20%. The residential sector accounted for nearly 50 million therms of non-programmatic savings through 2030. The commercial and government sectors accounted for nearly 11 million therms of non-programmatic savings through 2030.
- **Estimates of building energy code impacts**: This concerns the BAU-based building codes on Wisconsin's Uniform Dwelling Code SPS 320-325 for the residential sectors and the International Energy Conservation Code, 2015 edition, for commercial and government sectors. There is uncertainty regarding the timing and content of future updates to Wisconsin's building codes. Cadmus evaluated new construction impacts associated with state building energy codes as part the scenario analysis for residential, commercial and government sectors. This comparison represents the difference in potential resulting from changes in state codes after omitting all naturally occurring potential. The two scenarios include the following:
  - **Residential.** Wisconsin's Uniform Dwelling Code SPS 320-325 changing to International Energy Conservation Code, 2015 edition.
  - **Commercial and government.** International Energy Conservation Code, 2015 edition (pending future code) reverting back to International Energy Conservation Code, 2009 edition (current code).
    - New construction residential technical potential would decrease by 6.2% and 3.7% for electric and natural gas technical potential, respectively, if Wisconsin adopted IECC 2015 for its residential code. Commercial and government sector new construction technical potential would increase by 13.7% and 19.1% for electric and natural gas technical potential, respectively, if Wisconsin does not adopt IECC 2015 for its commercial code. Because new construction projects make up a relatively small share of total facilities in the state, effects on overall potential are much lower. Overall residential potential would decrease by 0.2% and 0.1% if Wisconsin adopted IECC 2015 for its residential code, and overall commercial potential would increase by 0.5% and 1.0% if Wisconsin does not adopt IECC 2015 for its commercial code, for the total electric and natural gas technical potential, respectively.

Portfolio Benchmarking

Cadmus conducted a benchmarking analysis of other utility jurisdictions' energy efficiency program portfolios and programs similar to those of Focus on Energy's portfolio and program attributes. The benchmarking findings support the potential study's gap analysis and ultimately assist Focus on Energy's staff in refining the energy efficiency program portfolio's development.

Approach

This section compares findings from other relevant energy efficiency program portfolios with Focus on Energy's current program portfolio. Researching publicly available information, Cadmus documented types of programs offered, portfolio funding and participation rates, savings, and program design considerations. Cadmus considered each best practice strategy based on its ability to cost-effectively contribute to the PSC's program goals, within the context of Focus on Energy's market conditions and program characteristics. Appendix E includes these benchmarking study sources.

Cadmus reviewed programs similar to Focus on Energy's, comparing relevant and available program designs and performance information, as listed in Table 37.

Table 37. Comparison of Energy Efficiency Program Portfolios

Program Sponsor	Program State	Utility Type(s)	Fuel Type(s)
Focus on Energy	Wisconsin	Investor-owned, municipal, and cooperative	Electric, natural gas
Commonwealth Edison	Illinois	Investor-owned	Electric
Consumers Energy	Michigan	Investor-owned	Electric, natural gas
EmPOWER Maryland	Maryland	Investor-owned, municipal and cooperative	Electric[1]
Energy Trust of Oregon	Oregon	Investor-owned and municipal	Electric, natural gas
Mass Save	Massachusetts	Investor-owned	Electric, natural gas
Xcel Energy	Minnesota	Investor-owned	Electric, natural gas

[1] For this study, Cadmus used EmPOWER's most current available report—the 2016 Standard Report—which documented results from 2015. EmPOWER began administering natural gas savings programs in 2016.

Cadmus identified five target utilities from which to gather data, ensuring each would match Focus on Energy's program portfolio for at least one of the following criteria:

- The program sponsor's service territory covers similar geography and/or demographics to that of Focus on Energy (e.g., it represented multiple utilities in a state).
- The program sponsor is a public power utility offering services in the Midwest.

Additionally, Cadmus chose to include utilities or portfolios that offer combined gas and electric programs and that have achieved notable performance, as reported in an American Council for an Energy-Efficient Economy (ACEEE) study of energy efficiency programs that save both electric and natural gas.[9] Table 38 lists the six comparison utilities and Cadmus' reasons for selecting them for the benchmarking study. Cadmus used industry reports, publicly available program information (e.g., program websites, report filings, evaluation reports), and institutional knowledge to collect data on the comparison utilities.

Table 38. Program Selection Criteria

Comparison Program	Geography and Demographics	Midwestern Utility	Programs with Coordinated Gas and Electric Savings
Commonwealth Edison		✓	✓
Consumers Energy		✓	✓
EmPOWER	✓		
Energy Trust of Oregon	✓		✓
Mass Save	✓		✓
Xcel Energy		✓	✓

Benchmarking Results

The benchmarking study examined the selected utilities for the following key elements:

- Portfolio penetration
- Portfolio impacts
- Residential program offerings
- Nonresidential program offerings

Additionally, Cadmus reviewed best practices for implementing successful energy efficiency programs and provided examples of how comparison utilities execute these actions.

Portfolio Penetration

Most comparison utilities possessed extensive experience in administering energy efficiency programs, many having offered energy efficiency portfolios for at least a decade. Table 39 and Figure 27 compare benchmarked utilities' electric service territories by customer type, as reported through the U.S. Energy Information Agency (EIA).

Readers should keep the following caveats in mind:

- While Commonwealth Edison (ComEd) commercial customers proved fairly comparable to a number of Focus on Energy commercial customers, the Illinois utility serves over a million more residential customers than Focus on Energy.

---

[9] Nowak, Seth, M. Kushler, and P. Witte. *Successful Practices in Combined Gas and Electric Utility Energy Efficiency Programs.* August 2014. Available online: http://aceee.org/research-report/u1406.

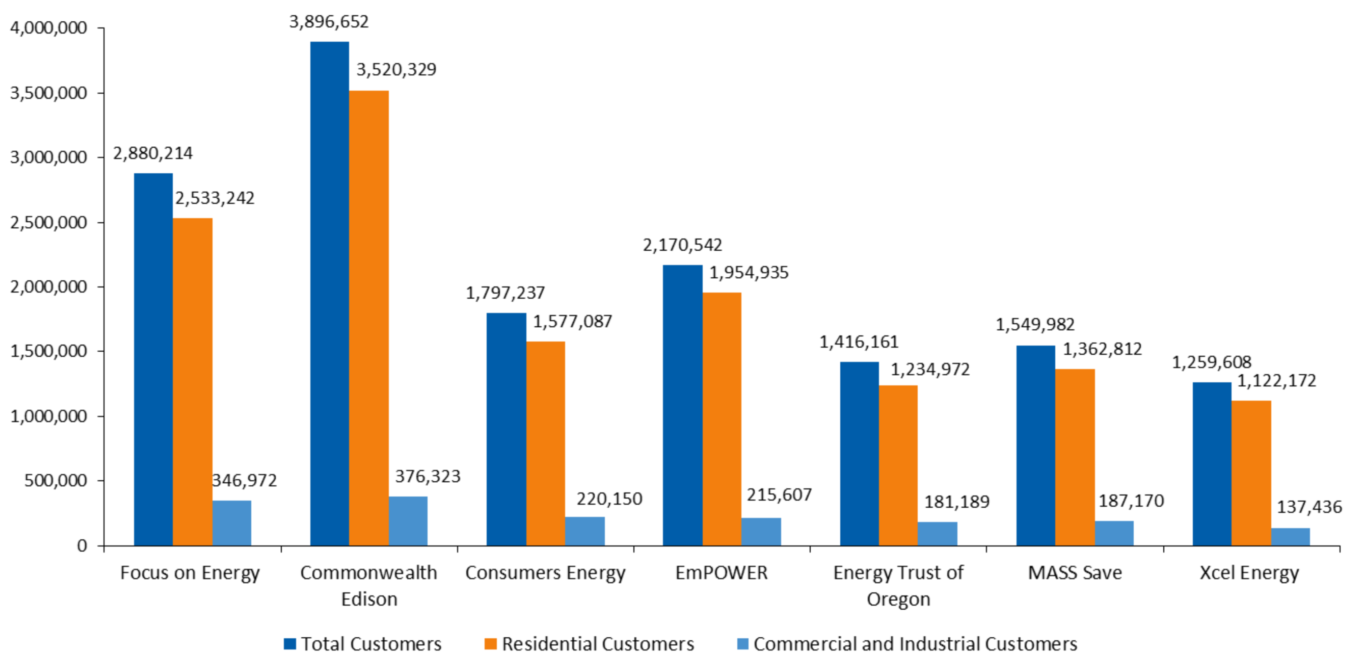
- Industrial customers made up nearly 1% of all of Energy Trust of Oregon's customers—half a percentage larger than that of the compared utility territories, including Focus on Energy.
- Overall, Focus on Energy had the second-largest customer base of the comparison utilities or portfolios.

Table 39. Comparison of 2015 Electric Utility Territory Customers

Program Sponsor	Participating Electric Utilities	Residential Customers	Commercial Customers	Industrial Customers	Total Customers
Focus on Energy (WI)	75	2,533,242	341,671	5,301	2,880,214
Commonwealth Edison (IL)	n/a	3,520,329	374,343	1,980	3,896,652
Consumers Energy (MI)	n/a	1,577,087	218,553	1,597	1,797,237
EmPOWER Maryland	5	1,954,935	209,742	5,865	2,170,542
Energy Trust of Oregon	2	1,234,972	168,517	12,672	1,416,161
Mass Save (MA)	3	1,362,812	182,186	4,984	1,549,982
Xcel Energy (MN)	n/a	1,122,172	136,937	499	1,259,608

Source: EIA 2015 Form 861 "Electric power sales, revenue, and energy efficiency." Focus on Energy's 108 participating utilities include three gas-only utilities and 30 electric municipal and cooperative utilities not required to report to EIA; therefore, these could not be included for comparison.

Figure 27. 2015 Electric Customers by Utility



Source: U.S. Energy Information Administration. EIA 2015 Form 861 "Electric power sales, revenue, and energy efficiency."

Portfolio Impacts

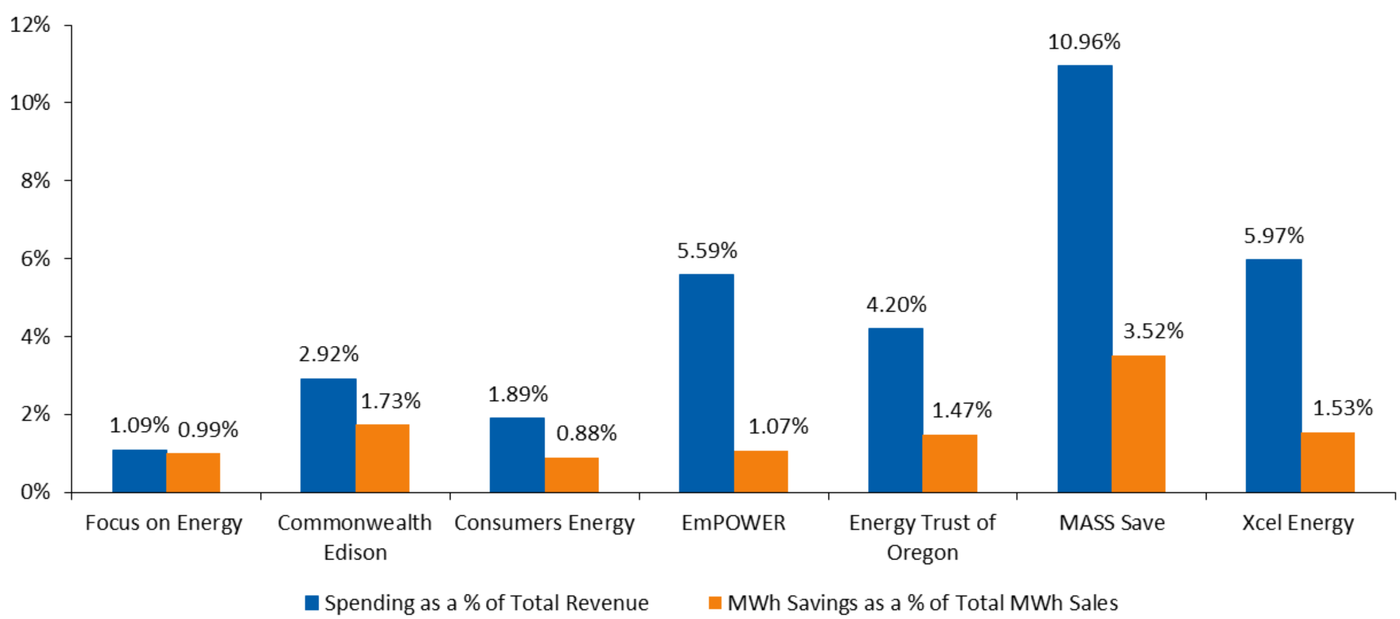
Table 40 and Figure 28 show relative energy efficiency spending and savings levels for Focus on Energy and for the comparison utilities or portfolios. For the group, average spending was 4.66% of total revenue, and, as a percentage of total MWh sales, average annual MWh savings were 1.60%. Focus on Energy had the lowest spending as a percentage of total revenue and was accordingly below average on electric savings as a percentage of sales.

Table 40. Comparison of 2015 Energy Efficiency Spending and Savings

Utility	Spending as a Percentage of Total Revenue	MWh Savings as a Percentage of Total MWh Sales
Focus on Energy	1.09%	0.99%
Commonwealth Edison	2.92%	1.73%
Consumers Energy	1.89%	0.88%
EmPOWER	5.59%	1.07%
Energy Trust of Oregon	4.20%	1.47%
Mass Save	10.96%	3.52%
Xcel Energy	5.97%	1.53%
Average	**4.66%**	**1.60%**

Source: EIA 2015 form 861.

Figure 28. Comparison of 2015 Electric Energy Efficiency Spending and Electric Savings



Cost of Energy Savings

Table 41 shows actual 2015 portfolio expenditures and savings reported by Focus on Energy and the comparison utilities. Cadmus normalized these results to show average costs per MWh saved by each utility or portfolio. The cost of running these energy efficiency portfolios ranged from $84 per MWh for ComEd to $382 per MWh for Xcel Energy. Among the benchmarked utilities and portfolios, Focus on Energy experienced the lowest electric spending and the second-lowest cost per saved MWh.

Table 41. 2015 Comparison of Cost of Electric Savings

Program Sponsor	Total Portfolio Electric Spending (Thousands of Dollars)	Total Portfolio Savings (MWh)	Cost per MWh Saved ($/MWh)
Focus on Energy	$77,752	661,814	$117.48
Commonwealth Edison	$126,426	1,496,319	$84.49
Consumers Energy	$76,162	324,493	$234.71
EmPOWER	$195,744	638,146	$306.74
Energy Trust of Oregon	$125,362	426,271	$294.09
Mass Save	$252,943	877,032	$288.41
Xcel Energy	$177,337	464,412	$381.85

Source: EIA 2015 form 861.

Using the most recently reported data available, Cadmus assessed the comparison portfolios' spending relative to their energy savings goals. Table 42 shows planned-to-actual energy savings reported by the comparison utilities for 2015 or 2016. Four of the eight portfolios exceeded their electric savings goals, while three of the five portfolios with natural gas savings programs exceeded their therm savings goals as of their last reporting cycles. As shown, Mass Save adopted the largest savings goals among portfolios compared, and, although it fell slightly below its therm goal, the portfolio exceeded its electric savings goals.

Table 42. Comparison of Planned to Actual Energy Savings

Program Sponsor	Program Year	Savings Goal	Actual Savings	Percentage to Goal
Focus on Energy				
MWh	2016	565,373	439,434	77.72%
Therms	2016	19,227,931	19,430,060	101.05%
Commonwealth Edison				
MWh	June, 2015-May, 2016	494,783	543,813	109.91%
Therms	June, 2015-May, 2016	-	-	-
Consumers Energy				
MWh	2015	380,730	324,493	85.23%
Therms	2015	20,987,980	20,106,377	95.80%
EmPOWER				
MWh	2015	719,469	638,146	88.70%

Program Sponsor	Program Year	Savings Goal	Actual Savings	Percentage to Goal
Therms	2015	-	-	-
Energy Trust of Oregon				
MWh	2016	473,571	525,600	110.99%
Therms	2016	5,721,145	6,292,363	109.98%
Mass Save				
MWh	2016	1,332,310	1,528,526	114.73%
Therms	2016	26,039,941	25,462,386	97.78%
Xcel Energy				
MWh	2016	438,289	626,068	142.84%
Therms	2016	6,731,990	9,026,400	134.08%

Sources available in Appendix E.

Funding available to reach the savings goals shown in Table 42 varied among the comparison utilities and portfolios. Wisconsin statute requires investor-owned utilities to contribute 1.2% of their annual operating revenues to fund the Focus on Energy programs. Energy efficiency program funding for ComEd and Consumers Energy represents 2.015% and 2% of the utilities' revenue, respectively. Minnesota statute requires that 2.0% of Xcel Energy's electric and 0.5% of gas-operating revenues be spent on energy efficiency programming. The Energy Trust of Oregon's funding is limited to up to 8% of utility revenues. Legislation in Massachusetts and Maryland does not set forth specific funding caps for the Mass Save and EmPOWER Maryland portfolios. Rather, Mass Save and EmPOWER Maryland utilities file plans that include budgets estimated as needed to cost-effectively capture the jurisdictional savings potential.

A 2014 ACEEE report reviewed the costs of running efficiency programs in 20 states, from 2009 to 2012 and found an average cost range of 13 to 42 cents per kWh, and 15 to 71 cents per therm, on a first-year acquisition cost basis.[10] Table 43 shows energy savings in cost per kWh and therm, as reported by comparison utilities for 2015 or 2016. All comparison utilities' costs per first-year kWh or therm fell within the ACEEE report's average range, except Xcel Energy's costs per therm.

Focus on Energy does not formally track costs by electric or natural gas savings but has adopted a longstanding rule of reporting spending for electric and natural gas savings at 80% and 20% of the total delivery costs, respectively. Based on this assumption, Focus on Energy's electric spending is $0.16 per kWh, which falls in the low range of the comparison utilities and portfolios, while spending to achieve natural gas savings is $0.91 per therm, which is higher than the comparison utilities and portfolios.

[10] American Council for an Energy-Efficient Economy. "New Report Finds Energy Efficiency is America's Cheapest Energy Resource." Last Modified March 25, 2014. http://aceee.org/press/2014/03/new-report-finds-energy-efficiency-a

Table 43. Comparison of Cost of Energy Savings

Program Sponsor	Year	Cost per Annual kWh ($/kWh)	Cost per Annual Therm ($/therm)
Focus on Energy	2016	$0.16	$0.91
Commonwealth Edison	2016	$0.17	n/a
Consumers Energy	2015	$0.31	$0.55
EmPOWER	2015	$0.31	n/a
Energy Trust of Oregon	2016	$0.30	$0.27
Mass Save	2016	$0.31	$0.16
Xcel Energy	2016	$0.14	$0.81

Residential Program Offerings

On average, the benchmarked service territories administered 41% of portfolio spending for residential programs delivery, consistent with the PSC's policy to allocate 40% of total Focus on Energy program budgets to the residential portfolio. As shown in Table 44, each comparison portfolio or utility (and Focus on Energy) offered a wide array of residential program offerings. Many of these offerings used similar design and delivery mechanisms. All comparison portfolios delivered lighting offers through an upstream design, where customers received incentives by purchasing qualified products from participating retailers at a discounted price, with the program reimbursing the retailer.

All three individual utilities (ComEd, Consumers Energy, and Xcel Energy) and EmPOWER Maryland implemented demand response programs to reduce peak power usage, typically through air conditioning cycling or time-of-use rates.[11] Three of the comparison utilities or portfolios—ComEd, Consumers Energy, and EmPOWER Maryland—offered behavioral programs that prompted customers to change their usage based on metered data.

Smart home devices—meters that residential customers purchase to obtain real-time energy feedback and modification—have started to establish a presence within energy efficiency and demand response programs. All but EmPOWER Maryland offered smart thermostat measures during the reporting year, with Xcel Energy offering incentives through a pilot program. Only ComEd offered incentives for other homeowner energy feedback measures (i.e., devices that can remotely assess and adjust energy usage of appliances, electronics, and heating and cooling equipment). ComEd delivered measures through an online marketplace, selling devices at discounted prices.

[11] Wisconsin Statute 196.374 defines energy efficiency programs as exclusive of load management. Therefore, Focus on Energy's residential and nonresidential portfolios do not include load management programs.

Table 44. Comparison of Residential Program Offerings

Residential Programs	Focus on Energy	Commonwealth Edison	Consumers Energy	EmPOWER Maryland	Energy Trust of Oregon	Mass Save	Xcel Energy
HVAC	✓	✓	✓	✓	✓	✓	✓
Insulation Rebate			✓		✓	✓	✓
Water Heater Rebate			✓	✓	✓	✓	✓
Efficient Products/ Appliances	✓	✓	✓	✓	✓	✓	
Appliance Recycling	✓	✓	✓	✓		✓	✓
Behavioral Modification		✓	✓	✓			
Energy Feedback		✓	✓				✓
Home Performance with ENERGY STAR	✓	✓	✓	✓	✓	✓	✓
Moderate Income/ Income Qualified	✓				✓	✓	
Multifamily	✓	✓	✓	✓	✓	✓	✓
Multifamily Low Income			✓			✓	
Multifamily Direct Install	✓	✓	✓			✓	
New Construction	✓		✓	✓	✓	✓	✓
Lighting	✓	✓	✓	✓	✓	✓	✓
Smart Thermostat	✓	✓	✓		✓	✓	✓
School Education Kits			✓				✓
Other Mailed Kits	✓		✓	✓	✓		
Online Store		✓				✓	✓
In-Home Energy Analysis with Direct Install		✓	✓	✓		✓	✓
Online Home Energy Audit			✓	✓	✓		✓
Air Conditioning Load Control		✓	✓	✓			✓
Other Load Control		✓		✓			
Time of Use Load Management		✓	✓				
Energy Efficiency Financing		✓			✓	✓	
Total Residential Offerings	**11**	**16**	**19**	**14**	**13**	**16**	**15**

Nonresidential Program Offerings

Table 45 compares nonresidential program offerings by utility. On average, 59% of portfolio spending was administered for commercial and industrial customers among the comparison utilities' service territories. All portfolios offered prescriptive, custom, and new construction programs for nonresidential customers. Focus on Energy offered a core program—Business Incentive Program— and programs based on customer type or energy usage (i.e., Large Energy Users, Agriculture, Schools and Government). While all of the comparison utilities or portfolios offered a new construction program, only Energy Trust of Oregon followed a similar customer-or-usage-centric program design. While the other comparison utilities or portfolios offered measures that customer segments use, such as agricultural or industrial process measures, they largely followed a technology-centric program design, offering programs to target specific measures or services. Four comparison portfolios—ComEd, EmPOWER Maryland, Mass Save, and Xcel Energy—offered midstream incentives as part of their lighting programs, primarily for LED lamp and downlight retrofit lighting measures. Customers received midstream lighting incentives as discounts through participating distributors.

Mass Save also took a different delivery approach to some lighting projects funded through its program. In addition to standard prescriptive and midstream incentives, program administrators provided an incentive based on the number of watts reduced in retrofits and on new construction projects with a lighting power density 10% below the energy code. Incentive levels increased for incorporating fixture-or-integral controls.

Table 45. Comparison of Nonresidential Program Offerings

Nonresidential Programs	Focus on Energy	Commonwealth Edison	Consumers Energy	EmPOWER Maryland	Energy Trust of Oregon	Mass Save	Xcel Energy
Business Standard Prescriptive	✓	✓	✓	✓	✓	✓	✓
Business Custom	✓	✓	✓	✓	✓	✓	✓
New Construction	✓	✓	✓	✓	✓	✓	✓
Agriculture Prescriptive	✓	✓	✓		✓		
Small Business Prescriptive	✓	✓	✓	✓			
Large Commercial and Industrial Prescriptive	✓					✓	✓
Business Retro-Commissioning	✓	✓	✓			✓	✓
Recommissioning							✓
Building Benchmarking			✓	✓	✓		
Small Business Direct Install	✓		✓	✓		✓	
Computer Efficiency	✓	✓					✓
Cooling Efficiency	✓	✓	✓	✓	✓	✓	✓
Data Center Efficiency	✓	✓			✓		✓

Nonresidential Programs	Focus on Energy	Commonwealth Edison	Consumers Energy	EmPOWER Maryland	Energy Trust of Oregon	Mass Save	Xcel Energy
Efficiency Controls	✓	✓	✓	✓		✓	✓
Fluid Systems Optimization (Compressed Air)	✓	✓				✓	✓
Foodservice Equipment	✓	✓	✓	✓	✓	✓	✓
Heating Efficiency	✓	✓	✓	✓	✓	✓	✓
Lighting Efficiency	✓	Midstream	✓	Midstream	✓	Midstream	Midstream
Motor Efficiency	✓	✓	✓	✓	✓	✓	✓
Process Efficiency	✓	✓	✓		✓	✓	✓
Refrigeration Efficiency	✓	✓	✓	✓	✓	✓	
Time of Use Load Management		✓					✓
Air Conditioning Load Control							✓
Energy Feedback (Opower)		✓	✓				
Financing[1]	✓	Small Business		Small Business		✓	✓
Business Education	✓		✓	✓			✓
Total Nonresidential Offerings	**18**	**20**	**18**	**15**	**13**	**16**	**20**

[1] Focus on Energy introduced a financing pilot in 2017.

Cadmus took a closer look at ComEd's and Xcel Energy's midstream lighting programs.

Xcel Energy: Business LED Rebate

Xcel Energy launched the midstream offer in its Colorado and Minnesota service territories in 2015. Xcel Energy funds the Business LED Rebate offers through its Lighting Efficiency Program and its small business programs—these are Small Business Lighting Program in Colorado and One-Stop Efficiency Shop in Minnesota. Through the Lighting Efficiency Program, Xcel Energy targets commercial customers with a peak demand of 400 kW or greater by offering prescriptive and custom rebates to help lower the upfront cost for installing qualified high-efficiency lighting equipment in new and existing buildings. The Colorado Small Business Lighting Program and Minnesota One-Stop Efficiency Shop serves non-managed customers with a peak demand of 400 kW or less.

For the Colorado program, Xcel Energy offered instant rebates for LED lamps and downlight fixtures, and customers must contribute at least $2.00 per lamp or kit. In Minnesota, Xcel Energy's offerings include LED lamps and downlight fixtures, LED high bay fixtures, and linear LED lamps, with the $2.00 customer co-payment introduced in 2017.

In both Colorado and Minnesota, the program implementer recruits and requires participating distributors to undergo program training and submit enrollment paperwork prior to offering instant rebates to customers. Distributors must meet eligibility criteria (they cannot be a manufacturer or retailer or perform primary sales via the internet). Xcel Energy requires distributors to obtain customer contact and account information and advises that "all lamps sold and submitted for reimbursement should be installed at the eligible customer's facility or premises within 30 days of the sale,"[12] which aligns with the timing of its random site visit process conducted as part of its M&V protocol. The distributor submits sales data to the program implementer via an electronic portal for reimbursement.

Commonwealth Edison: Midstream Incentives Program

ComEd launched its midstream incentive offers as a pilot in June 2010 and as a full program offer in June 2011. Business customers in ComEd's service territory are eligible to receive midstream prescriptive incentives for lighting equipment through its Business Instant Lighting Discounts Program (ComEd also offers midstream incentives for commercial battery chargers through its Business Products Discounts Program).

In November 2015, ComEd implemented a customer co-payment mechanism, where distributors require customers to pay their distributor or contractor at least 50% of the incentive amount for products. While this process helps mitigate program oversubscription, it requires ComEd to regularly monitor incentive amounts paid for products because an increase in the number of sales with this minimum price point could indicate declines in market pricing, which means that participants would pay for products at above-market values.

Distributors provide all incentives as a discount on the original sale and submit required sales data within 15 days for program reimbursement. In a survey of participating distributors (n=75), 55% said the 15-day deadline is reasonable, while the remainder suggested 30 days. In June 2015, ComEd began requiring distributors to submit business customer contact information as part of the fulfillment process. ComEd offered funding in 30-, 45-, and 60-day intervals to maintain a forecast of distributors' sales activities. Through distributor surveys, the program evaluator found that over 80% of distributors could reasonably estimate program funding needs within these intervals.

[12] Xcel Energy. "Business LED Instant Rebate." Accessed June 2017: https://www.xcelenergy.com/working_with_us/trade_partners/business_trade_partners/business_led_instant_rebate

Gap Analysis

Cadmus performed an end-use and measure-level gap analysis, which compared measures currently offered through Focus on Energy's residential and commercial energy efficiency programs to efficiency measures assessed in the potential study. The measure gap analysis sought to achieve three objectives in order to inform portfolio planning:

- Identify cost-effective measures
- Identify gaps by comparing cost-effective measures offering notable potential to those provided by current programs
- Identify nearly cost-effective measures

Identification of Cost-Effective and Nearly Cost-Effective Measures

For each measure in the potential study, Cadmus determined cost-effectiveness using Focus on Energy's MTRC test ratio and then calculated a savings-weighted B/C ratio for each potential study measure across fuel savings types, construction vintages, and the following sectors and segments:

- Three housing segments for residential applications (e.g., single-family, multifamily in-unit, manufactured homes)
- Nineteen building types for commercial and government applications, including multifamily common areas
- Agriculture sector

A measure may be cost-effective for some combinations of these variables and not cost-effective for other combinations. Cadmus identified measures where measure iterations never attained achievable potential (i.e., a TRC test ratio greater than or equal to 1.0), and where at least one measure iteration (segment, vintage, and end use) attained a TRC test ratio between 1.0 and 0.7. These may become measures of interest moving forward, depending on continued product and market developments and program designs, which are only required to meet a portfolio-level cost-effectiveness standard.

Cadmus did not perform a gap analysis for the industrial sector since industrial energy efficiency projects tend to be custom where all cost-effective measures are applicable. In addition, the industrial measure list is less discrete (e.g., general measure categories) than commercial prescriptive measures so making meaningful comparisons is difficult.

Identification and Mapping of Current Measures

Cadmus reviewed measures within the Wisconsin Focus on Energy TRM and the Statewide Program for Energy Customer Tracking, Resource Utilization and Data Management (SPECTRUM) database to compile a complete list of measure offerings for the residential and commercial sectors, current as of 2016. Cadmus then aligned the potential study measures with currently offered program measures.

Notably, aligning energy efficiency program measures with those in a potential study cannot be considered an exact science. For example, a residential appliance rebate program may offer an incentive for ENERGY STAR refrigerators. A potential study, however, models energy savings on a much more granular level, typically involving multiple tiers of ENERGY STAR refrigerators. In most cases, Cadmus' potential studies involve a broad range of program-qualifying measures that do not directly correspond with individual program offerings.

Analysis

Cadmus mapped Focus on Energy's currently offered measures to potential measures then analyzed the results to determine the following:

- Currently offered measures with achievable potential, which Focus on Energy should continue offering
- Currently offered measures with little or no technical achievable potential, which Focus on Energy may wish to review and to assess whether offerings should be included in programs through bundling with more cost-effective measures, whether cost-effectiveness and achievability may change under future policy or market changes, or whether offerings should be discontinued
- Measures demonstrating high potential and cost-effectiveness, which Focus on Energy currently does not offer and which could be added to program offerings
- Measures that are nearly cost-effective, which may be of interest to Focus on Energy moving forward, depending on continued developments and program designs

Residential Sector

Current Measures with Achievable Potential

Table 46 and Table 47 list the residential electric and gas measures currently offered by Focus on Energy and that Cadmus determined as cost-effective with BAU achievable potential. These tables organize measures by measure groups, listing them from their highest to lowest share of total residential achievable potential:

- Advanced power strips account for 18% of total residential achievable potential.
- Refrigerator removals and LED interior specialty lighting account for 16% and 15%, respectively.
- Residential measures currently offered by Focus on Energy account for 84% of total residential electric achievable potential.
- Measures not currently offered by Focus on Energy account for the remaining 16% of residential electric achievable potential.

Table 46. Currently Offered Residential Electric Measures with Achievable Potential

Measure Group	Measure Name from Potential Study[1]	Total Cumulative BAU Achievable Potential (MWh)	Share of Total Achievable Potential	
			Measure	Measure Group
Advanced Power Strip	Smart Strip Plug Outlet	444,591	17.98%	17.98%
Refrigerator - Removal	Refrigerator - Removal of Secondary	402,905	16.29%	16.29%
Lighting Interior Specialty	Lighting Specialty Lamp - Premium Efficiency LED	374,858	15.16%	15.16%
Lighting Standard	Lighting General Service Lamp - Premium Efficiency LED	254,955	10.31%	10.31%
Faucet Aerator	Faucet Aerator Low Flow - Kitchen	104,558	4.23%	6.69%
	Faucet Aerator Low Flow - Bathroom	60,864	2.46%	
Low-Flow Showerhead	Low-Flow Showerhead	143,886	5.82%	5.82%
Freezer - Removal	Freezer - Removal of Stand-Alone	135,684	5.49%	5.49%
Thermostat	Wi-Fi Thermostat	32,070	1.30%	1.77%
	Wi-Fi Thermostat - Seasonal Savings	11,741	0.47%	
Lighting Linear Fluorescent	Linear Fluorescent Lamp - High Performance T8	27,363	1.11%	1.11%

[1] Table includes only measures with greater than or equal to 1% of the total achievable potential.

Thermostats account for 22% of the total residential natural gas BAU achievable potential, while low-flow showerheads and faucet aerators account for 20% and 19%, respectively. Residential measures currently offered by Focus on Energy account for 75% of total residential natural gas BAU achievable potential during the study period. Measures not currently offered by Focus on Energy account for the remaining 25% of residential natural gas BAU achievable potential.

Table 47. Currently Offered Residential Natural Gas Measures with Achievable Potential

Measure Group	Measure Name from Potential Study[1]	Total Cumulative BAU Achievable Potential (therms)	Share of Total Achievable Potential	
			Measure	Measure Group
Thermostat	Wi-Fi Thermostat	19,967,800	15.54%	21.93%
	Wi-Fi Thermostat - Seasonal Savings	8,214,872	6.39%	
Low-Flow Showerhead	Low-Flow Showerhead	25,471,288	19.82%	19.82%
Faucet Aerator	Faucet Aerator Low Flow - Kitchen	15,328,687	11.93%	19.14%
	Faucet Aerator Low Flow - Bathroom	9,267,535	7.21%	
Duct	Duct Sealing and Insulation - WI UDC Zone 1 and 2 Code	8,910,839	6.93%	6.93%
Heat Central Gas Furnace	Furnace - Premium Efficiency	4,764,048	3.71%	3.71%
Insulation - Boiler Pipe	Pipe Insulation - Boiler - Code	2,341,377	1.82%	2.05%
	Pipe Insulation - Boiler - Above Code	296,953	0.23%	

[1] Table includes only measures with greater than or equal to 1% of the total achievable potential.

Notably, some emerging technology measure iterations (e.g., combinations of fuel savings types, construction vintages, building segments) passed the cost-effectiveness screen. Heat pump water heaters,[13] cold climate heat pumps, and insulating concrete form construction attained achievable potential. As these measures fell below 1% of the achievable potential, Table 46 and Table 47 do not include them, but they will likely serve as measures of interest moving forward due to continued product and market developments.

Current Measures without Achievable Potential

The potential study revealed that several measures currently offered by Focus on Energy did not pass the cost-effectiveness screening. Hence, they did not offer achievable potential. Cadmus grouped the measures' total technical potential at these measure-group levels, as shown in Table 48 and Table 49.

Table 48. Currently Offered Residential Electric Measures Without Achievable Potential

Measure Group	Measure Name	Cumulative Technical Potential (MWh) by Measure	Technical Potential (MWh) by Measure Group
Insulation - Ceiling	Ceiling Insulation - WI UDC Zone 1 and 2 above Code	34,647	66,050
	Ceiling Insulation - WI UDC Zone 1 and 2 Code	21,515	
	Ceiling Insulation - Maximum Feasibility	9,889	
Window Improvement	Window - WI UDC Zone 1 and 2 Code	47,042	48,813
	Window - WI UDC Zone 1 and 2 above Code - ENERGY STAR	1,772	
	Window - WI UDC Zone 1 and 2 above Code	0	
Insulation - Rim and Band Joist	Rim And Band Joist Insulation - WI UDC Zone 1 Code	5,211	8,222
	Rim And Band Joist Insulation - Maximum Insulation Feasible	2,541	
	Rim And Band Joist Insulation - WI UDC Zone 2 Code	471	

[13] Due to the breakout of the water heating end uses by fuel type and tank size, it is worth clarifying where each residential water heating end use falls in terms of the gap analysis categories. The following water heating measure groups currently offered by Focus on Energy attained less than 1% of the total achievable potential for their respective fuel types: electric water heat, with less than or equal to 55 gallon tank size; electric water heat, with greater than 55 gallon tank size; and gas water heat, with greater than 55 gallon tank size. As shown in Table 49, gas water heat with less than or equal to 55 gallon tank size is a measure group currently offered by Focus on Energy that does not attain achievable potential.

Table 49. Currently Offered Residential Natural Gas Measures Without Achievable Potential

Measure Group	Measure Name	Cumulative Technical Potential (therms) by Measure	Technical Potential (MWh) by Measure Group
Insulation - Ceiling	Ceiling Insulation - WI UDC Zone 1 and 2 Code	21,635,302	26,748,509
	Ceiling Insulation - Maximum Feasibility	4,587,796	
	Ceiling Insulation - WI UDC Zone 1 and 2 above Code	525,411	
Window Improvement	Window - WI UDC Zone 1 and 2 Code	25,364,903	26,078,554
	Window - WI UDC Zone 1 and 2 above Code - ENERGY STAR	713,651	
	Window - WI UDC Zone 1 and 2 above Code	0	
Water Heat LE 55 Gal	Water Heater - ENERGY STAR Tankless	17,086,354	17,434,678
	Water Heater - Condensing	297,217	
	Water Heater - ENERGY STAR Storage	51,107	
Insulation - Rim and Band Joist	Rim And Band Joist Insulation - WI UDC Zone 1 Code	5,148,272	8,154,582
	Rim And Band Joist Insulation - Maximum Insulation Feasible	2,539,829	
	Rim And Band Joist Insulation - WI UDC Zone 2 Code	466,480	
Indirect Water Heater	Indirect Water Heater - Tier 2	4,130,592	4,130,592
	Indirect Water Heater - Tier 1	0	
Boiler Controls	Boiler - Controls	4,099,814	4,099,814
Integrated Heat	Integrated Space Heating and Water Heating	2,787,529	2,787,529
Tune Up HVAC	Tune-up - Boiler	1,607,835	1,607,835
Insulation - Slab	Slab Insulation - Above Code	191,491	191,491

Cadmus identified some measures in Table 48 and Table 49 as nearly cost-effective; these are ceiling insulation, rim and band joist insulation, indirect water heaters, and integrated space and water heating. For a complete list of nearly cost-effective measures, see the Nearly Cost-Effective Measures section.

Potential Study Measures with Achievable Potential Not Currently Offered

Table 50 and Table 51 list residential measures not currently offered by Focus on Energy that Cadmus found cost-effective with BAU achievable potential. The tables organize these measures by measure groups, listing them from their highest to lowest share of total residential BAU achievable potential. Behavioral “energy feedback” measures, which provide users with information designed to change their usage habits, account for 7% of total residential electric BAU achievable potential, while clothes washers account for 1.5% of total residential electric BAU achievable potential. Residential measures not currently offered by Focus on Energy account for 16% of total residential electric BAU achievable potential.

Table 50. Not Currently Offered Residential Electric Measures with Achievable Potential

Measure Group	Measure Name from Potential Study[1]	Total Cumulative BAU Achievable Potential (MWh)	Share of Total Achievable Potential	
			Measure	Measure Group
Energy Feedback	Energy Feedback Residential - HVAC Schedule Setback	50,179	2.03%	7.29%
	Energy Feedback Residential - Lighting HOU Reduction	42,528	1.72%	
	Energy Feedback Residential - Enable Computer Sleep Settings	40,911	1.65%	
	Energy Feedback Residential - Reduce Brightness of TV	30,621	1.24%	
	Energy Feedback Residential - Water Heat Temperature Setback	8,688	0.35%	
	Energy Feedback Residential - Minutes per Shower Reduction	7,295	0.29%	
Clothes Washer Electric	Clothes Washer (Top Loading) - CEE Tier 3	27,683	1.12%	1.49%
	Clothes Washer (Front Loading) - CEE Tier 3	9,140	0.37%	
Dryer	Dryer - Heat Pump Dryer	29,030	1.17%	1.17%

[1] Table only includes measures with greater than or equal to 1% of the total achievable potential.

Behavioral "energy feedback" measures account for 12% of total residential natural gas BAU achievable potential, while programmable thermostats account for 6% of total residential natural gas BAU achievable potential. Residential measures not currently offered by Focus on Energy account for 25% of total residential natural gas BAU achievable potential.

Table 51. Not Currently Offered Residential Natural Gas Measures with Achievable Potential

Measure Group	Measure Name from Potential Study[1]	Total Cumulative BAU Achievable Potential (therms)	Share of Total Achievable Potential	
			Measure	Measure Group
Energy Feedback	Energy Feedback Residential - HVAC Schedule Setback	10,161,204	7.91%	12.27%
	Energy Feedback Residential - Water Heat Temperature Setback	4,122,814	3.21%	
	Energy Feedback Residential - Minutes per Shower Reduction	1,487,653	1.16%	
Thermostat[2]	Programmable Thermostat	7,610,159	5.92%	5.92%
Door	Door - WI UDC Zone 1 and 2 Above Code	4,166,549	3.24%	3.24%
Insulation - Floor	Floor Insulation - WI UDC Zone 1 Code	2,604,337	2.03%	2.03%
Clothes Washer Gas	Clothes Washer (Front Loading) - CEE Tier 3	1,485,205	1.16%	1.16%

[1] Table only includes measures with greater than or equal to 1% of the total achievable potential.
[2] Focus on Energy has started offering programmable thermostats as kit options under the rural/broadband programs starting in 2017.

Commercial and Government Sector

Current Measures with Achievable Potential

Table 52 and Table 53 list measures currently offered by Focus on Energy that Cadmus determined have achievable potential (and are cost-effective). The lighting measure groups account for 42% of total commercial and government electric BAU achievable potential. Variable speed pump and fan measures account for 7% of total commercial and government electric BAU achievable potential. Commercial and government measures currently offered by Focus on Energy account for 82% of total commercial and government electric BAU achievable potential during the study period. Measures not currently offered by Focus on Energy account for the remaining 18% of commercial and government electric BAU achievable potential.

Table 52. Currently Offered Commercial and Government Electric Measures with Achievable Potential

Measure Group	Measure Name from Potential Study[1]	Total Cumulative BAU Achievable Potential (MWh)	Share of Total Achievable Potential	
			Measure	Measure Group
Lighting Controls	Occupancy Sensor Control	348,415	16.34%	23.37%
	Parking - Surface Lighting	69,777	3.27%	
	Time Clock	27,427	1.29%	
	Dimming-Stepped, Fluorescent Fixtures	20,267	0.95%	
	Dimming-Continuous, Fluorescent Fixtures	19,047	0.89%	
	Parking - Covered Lighting	7,837	0.37%	
	Bi-Level Control, Parking Garage Lighting	5,621	0.26%	
Lighting Interior Fluorescent	Lighting Interior - TLED - Above Standard	223,015	10.46%	10.46%
Lighting Interior Screw Base - Standard	Lighting Interior - Screw Base LED - Above Standard	167,690	7.86%	7.86%
Variable Speed HVAC Pump and Fans	Fan System - HVAC - Variable Speed Control	55,946	2.62%	7.06%
	Pump System - HVAC Heating Pump - Variable Speed Control	30,264	1.42%	
	Variable Speed ECM Pump - HVAC Space Cooling Recirculation	20,852	0.98%	
	Variable Speed ECM Pump - HVAC Space Heating Recirculation	17,914	0.84%	
	Pump System - Chiller - Variable Speed Control	12,845	0.60%	
	Cooling Tower - VSD Fan Control	5,990	0.28%	
	Variable Speed ECM Pump - Domestic Hot Water Recirculation	5,874	0.28%	
	Variable Speed ECM Pump - HVAC Heat Pump Recirculation	958	0.04%	
Refrigerator and Freezer - Commercial Sized	Glass Door ENERGY STAR Refrigerators/Freezers	66,001	3.09%	3.63%
	Solid Door ENERGY STAR Refrigerators/Freezers	11,373	0.53%	
CV to VAV	Convert Constant Volume Air System to VAV	70,782	3.32%	3.32%
LED Exterior Lighting	LED Exterior Flood Lights	45,760	2.15%	3.16%
	LED Pathway Lights	21,685	1.02%	

Measure Group	Measure Name from Potential Study[1]	Total Cumulative BAU Achievable Potential (MWh)	Share of Total Achievable Potential	
			Measure	Measure Group
Exit Signs	Exit Sign - LED	40,021	1.88%	1.88%
Direct Digital Control System	Direct Digital Control System-Installation	37,548	1.76%	1.76%
Lighting Interior HID	Lighting Interior - High Bay LED - Above Standard	32,805	1.54%	1.54%
Anti-Sweat Controls	Anti-Sweat (Humidistat) Controls	30,739	1.44%	1.44%
Lighting Interior Other	New Construction Lighting Package - Advanced Efficiency	27,033	1.27%	1.27%
Walk-In ECM	Walk-In Electronically Commutated Motor	24,955	1.17%	1.17%
Refrigeration Commissioning	Refrigeration Commissioning or Recommissioning	22,747	1.07%	1.07%

[1]Table only includes measures with greater than or equal to 1% of the total achievable potential.

Direct digital control systems account for 20% of total commercial and government gas BAU achievable potential. Wi-Fi thermostats account for 16% of total commercial and government gas BAU achievable potential. Commercial and government measures currently offered by Focus on Energy account for 78% of total commercial and government gas BAU achievable potential. Measures not currently offered by Focus on Energy account for the remaining 22% of commercial and government gas BAU achievable potential.

Table 53. Currently Offered Commercial and Government Natural Gas Measures with Achievable Potential

Measure Group	Measure Name from Potential Study[1]	Total Cumulative BAU Achievable Potential (MWh)	Share of Total Achievable Potential	
			Measure	Measure Group
Direct Digital Control System	Direct Digital Control System-Installation	24,114,847	20.17%	20.17%
HVAC Thermostat	Wi-Fi Thermostat	19,619,654	16.41%	16.41%
Ceiling Insulation	Insulation - Ceiling - IECC 2015 - Zone 6 Code	3,770,867	3.15%	5.78%
	Insulation - Ceiling - IECC 2015 - Zone 6 Above Code	2,761,658	2.31%	
	Insulation - Ceiling - IECC 2015 - Zone 7 Code	377,699	0.32%	

Measure Group	Measure Name from Potential Study[1]	Total Cumulative BAU Achievable Potential (MWh)	Share of Total Achievable Potential	
			Measure	Measure Group
Automated Ventilation CO2 Sensors	Automated Ventilation VFD Control (Occupancy Sensors / CO2 Sensors)	5,537,580	4.63%	4.63%
Boiler VFD Draft Fan	Boiler Draft Fan - VFD	4,082,418	3.41%	3.41%
Water Heater Setback Thermostat	Water Heater Setback Thermostat	3,770,740	3.15%	3.15%
Space Heat - Gas Furnace	Furnace < 225 kBtuh - Advanced Efficiency	2,831,289	2.37%	3.12%
	Furnace < 225 kBtuh - Premium Efficiency	904,363	0.76%	
HVAC Commissioning	Retro-commissioning	3,730,721	3.12%	3.12%
Space Heat - Gas Boiler	Boiler < 300 kBtuh - Advanced Efficiency	2,035,835	1.70%	2.84%
	Boiler >= 300 and <= 2,500 kBtuh - Premium Efficiency	1,362,270	1.14%	
	Boiler < 300 kBtuh - Federal Standard 2022	2,426	0.002%	
Wall Insulation	Insulation - Wall - IECC 2015 - Zone 6 and 7 Above Code	2,885,526	2.41%	2.69%
	Insulation - Wall - IECC 2015 - Zone 6 and 7 Code	333,597	0.28%	
Cooking Equipment	Fryers	1,044,329	0.87%	2.56%
	Steam Cooker	734,386	0.61%	
	Rack Oven	726,743	0.61%	
	Convection Oven	371,280	0.31%	
	Combination Oven	186,349	0.16%	
Behavioral Energy Management	Behavioral Energy Management	2,768,058	2.32%	2.32%
Infiltration Reduction	Infiltration Reduction	2,426,145	2.03%	2.03%
Garage Door Hinges	Garage Door Hinges - Spring-Loaded	2,072,397	1.73%	1.73%

[1] Table only includes measures with greater than or equal to 1% of the total achievable potential.

Some emerging technology measure iterations (e.g., combinations of fuel savings types, construction vintages, building segments) passed the cost-effectiveness screen. Residential-sized heat pump clothes dryers, HVAC variable refrigerant flow, active chilled beam cooling with dedicated outside air system, and gas dryers with modulating controls attained achievable potential. As these measures fall below 1%

of achievable potential, they are not included in Table 52 or Table 53. They will likely, however, be measures of interest moving forward due to continued product and market developments.

Current Measures without Achievable Potential

The potential study revealed several measures currently offered by Focus on Energy that did not pass the cost-effectiveness screening test (i.e., MTRC) and therefore do not have achievable potential. Given the large number of measure iterations across building types, construction vintages, and efficiency levels, Cadmus grouped the total technical potential at the measure group level for existing measure offerings, as shown in Table 54. Although these measures did not pass the MTRC, they remain of interest to Focus on Energy—not only if product and market developments continue but as part of program designs that support well-rounded and robust offerings to meet other program goals and to maintain overall cost-effectiveness of programs through bundling with other measures.

Table 54. Currently Offered Commercial and Government Electric Measures Without Achievable Potential

Measure Group	Measure Name	Cumulative Technical Potential (MWh) by Measure	Technical Potential (MWh) by Measure Group
Ice Maker	Ice Maker - High Efficiency	32,760	32,760
Cooking Hood Controls	Cooking Hood Controls	22,188	22,188
Cooling Tower - VSD Fan	Cooling Tower Fan - Variable Speed Control	15,382	15,382
Demand Control Defrost	Demand Control Defrost - Hot Gas	10,509	10,509
Hotel Key Card Control System	Hotel Key Card Room Energy Control System	4,113	4,113
Chilled Water Reset	Chilled Water Reset	2,411	2,411
Liquid Desiccant Air Conditioner	Liquid Desiccant Air Conditioner (LDAC)	903	903
Display Case Add Doors	Add Doors to Refrigerated Open Display Cases	65	65
Reverse Cycle Chillers	Reverse Cycle Chillers for Multi-Family	35	35

Table 55. Currently Offered Commercial and Government Natural Gas Measures Without Achievable Potential

Measure Group	Measure Name	Cumulative Technical Potential (therms) by Measure	Technical Potential (MWh) by Measure Group
Air-to-Air Heat Recovery	Exhaust Air to Ventilation Air Heat Recovery	4,999,636	4,999,636
Strategic Energy Management	Strategic Energy Management (SEM)	3,062,776	3,062,776
Boiler Oxygen Trim Controls	Boiler Oxygen Trim Controls	1,753,526	1,753,526
Room Heat - Gas	Radiant Heater - High Efficiency	1,476,353	1,476,353
Boiler Pipe Insulation	Boiler - Pipe Insulation - Code	122,030	160,014

Measure Group	Measure Name	Cumulative Technical Potential (therms) by Measure	Technical Potential (MWh) by Measure Group
	Boiler - Pipe Insulation - Above Code	37,984	1,476,353
Reverse Cycle Chillers	Reverse Cycle Chillers for Multi-Family	12,447	12,447

Cadmus identified some measures in Table 54 and Table 55 as nearly cost-effective. These are cooling tower VSD fan, air-to-air heat recovery, hotel key card control system, reverse cycle chillers for multifamily. For a complete list of nearly cost-effective measures, see the Nearly Cost-Effective Measures section.

Potential Study Measures with Achievable Potential Not Currently Offered

Table 56 and Table 57 list measures not currently offered (as of the 2016 program year) by Focus on Energy but that Cadmus determined have achievable potential (and are cost-effective). Refrigeration walk-in economizers account for 3% of total commercial and government electric achievable potential, while variable air volume (VAV) box electronically commutated motors (ECMs) account for 2.5% of total commercial and government electric achievable potential. Commercial and government measures not currently offered by Focus on Energy account for 18% of total commercial and government electric BAU achievable potential.

Table 56. Not Currently Offered Commercial and Government Electric Measures with Achievable Potential

Measure Group	Measure Name from Potential Study[1]	Total Cumulative BAU Achievable Potential (MWh)	Share of Total Achievable Potential	
			Measure	Measure Group
Refrigeration Economizer	Walk-in Economizer	67,085	3.15%	3.15%
VAV Box ECM[2]	Motor - VAV Box High Efficiency (ECM)	54,995	2.58%	2.58%
LED Signage[2]	LED or equivalent sign lighting	47,960	2.25%	2.25%
Display Case Replacement	Case Replacement Low Temp	32,555	1.53%	1.66%
	Case Replacement Med Temp	2,776	0.13%	
Advanced Lighting and Controls Design[3]	Advanced Lighting and Controls Design	30,513	1.43%	1.43%
Internal Power Supply	Internal Power Supply / Server	12,947	0.61%	1.08%
	Internal Power Supply / Com - E Star	10,155	0.48%	

[1] Table only includes measures with greater than or equal to 1% of the total achievable potential.

[2] Focus on Energy has started offering these measures in 2017.

[3] Focus on Energy has started a pilot for advanced lighting and controls starting in 2017.

Integrated space and water heaters and duct repairs/sealing each account for 5% of total commercial and government gas achievable potential. Commercial and government measures not currently offered by Focus on Energy account for 22% of total commercial and government gas BAU achievable potential.

Table 57. Not Currently Offered Commercial and Government Natural Gas Measures with Achievable Potential

<table>
<tr><th rowspan="2">Measure Group</th><th rowspan="2">Measure Name from Potential Study[1]</th><th rowspan="2">Total Cumulative BAU Achievable Potential (therms)</th><th colspan="2">Share of Total Achievable Potential</th></tr>
<tr><th>Measure</th><th>Measure Group</th></tr>
<tr><td>Integrated Space Heating and Water Heating</td><td>Integrated Space Heating and Water Heating</td><td>6,380,936</td><td>5.34%</td><td>5.34%</td></tr>
<tr><td>Duct Repair and Sealing</td><td>Duct Repair and Sealing</td><td>5,496,308</td><td>4.60%</td><td>4.60%</td></tr>
<tr><td>HVAC Commissioning</td><td>Recommissioning</td><td>4,252,042</td><td>3.56%</td><td>3.56%</td></tr>
<tr><td>HVAC Economizer</td><td>Boiler - Economizer</td><td>3,860,645</td><td>3.23%</td><td>3.23%</td></tr>
<tr><td rowspan="3">Floor Insulation</td><td>Insulation - Floor (non-slab) - IECC 2015 - Zone 6 Above Code</td><td>1,107,935</td><td>0.93%</td><td rowspan="3">1.64%</td></tr>
<tr><td>Insulation - Floor (non-slab) - IECC 2015 - Zone 6 Code</td><td>755,316</td><td>0.63%</td></tr>
<tr><td>Insulation - Floor (non-slab) - IECC 2015 - Zone 7 Code</td><td>92,128</td><td>0.08%</td></tr>
<tr><td>Duct Insulation</td><td>Insulation - Duct - IECC 2015 - Zone 6 and 7 Code</td><td>1,622,683</td><td>1.36%</td><td>1.36%</td></tr>
</table>

[1] Table only includes measures with greater than or equal to 1% of the total achievable potential.

Agriculture Sector

Table 58 lists agricultural electric and gas measures that Cadmus determined as cost-effective with achievable potential. This table organizes measures by measure name, listing them from their highest to lowest share of total agricultural BAU achievable potential:

Table 58. Agriculture Measures with Achievable Potential

Measure Name from Potential Study[1]	Offered by Focus on Energy	Total Cumulative BAU Achievable Potential (MWh, therms)	Share of Total Achievable Potential
Electric End Use Fuel Type			
VFD, Ventilation/Circulation Fan	Yes	32,818	14.20%
High-Volume Low-Speed (HVLS) Fan	Yes	27,953	12.10%
Lighting - High Bay LED Packages	Yes	22,272	9.64%
Lighting - Lamp (Screw Base) LED	Yes	19,972	8.64%

Measure Name from Potential Study[1]	Offered by Focus on Energy	Total Cumulative BAU Achievable Potential (MWh, therms)	Share of Total Achievable Potential
Water Heater Electric Upgrade	No	17,036	7.37%
Ventilation/Exhaust Fan	Yes	15,311	6.62%
Lighting Controls - Occupancy Sensors, Photocell Controls, And Timers	Yes	35,672	5.65%
Lighting - Linear LED Packages	Yes	30,384	5.38%
Low Energy Spray Application	No	24,209	4.57%
VFD, Agriculture Primary and Secondary Use Water System	Yes	21,709	4.54%
Variable Speed Control Vacuum Pump (Dairy Farm, Parlor, Milk House)	Yes	18,517	4.25%
Plate Heat Exchanger and Well Water Pre-Cooler (Dairy Farm, Parlor, Milk House)	Yes	16,642	4.17%
VFD for Agriculture Process Pump, Constant Torque, or Irrigation Well Pump	Yes	14,183	4.03%
Scroll Compressor Replacement (Dairy Farm, Parlor, Milk House)	Yes	13,505	2.15%
Irrigation Pressure Reduction	Yes	11,470	1.97%
Engine Block Heater Timer	Yes	11,403	1.49%
Natural Gas End Use Fuel Type			
Refrigeration Heat Recovery Unit (Gas)	Yes	68,572	86.10%
Thermal Curtain (Natural Gas Only)	Yes	8,845	11.11%
Greenhouse Unit Heater (Natural Gas Only), >= 90% thermal efficiency, per input MBh, for retrofit	No	2,213	2.78%

[1] Table only includes measures with greater than or equal to 1% of the total achievable potential.

Focus on Energy's current measure offerings capture most of the agricultural electric and natural gas BAU achievable potential. VFDs for ventilation and circulation fans account for 14% of total agricultural electric achievable potential. High-volume low-speed fans account for 12% of total agricultural electric BAU achievable potential. Agricultural measures currently offered by Focus on Energy account for 88% of total agricultural electric BAU achievable potential. Measures not currently offered by Focus on Energy account for the remaining 12% of agricultural electric BAU achievable potential.

Refrigeration heat recovery units account for 86% of total agricultural natural gas BAU achievable potential. Thermal curtains account for 11% of total agricultural natural gas BAU achievable potential. Agricultural measures currently offered by Focus on Energy account for 97% of total agricultural natural gas BAU achievable potential during the study period. Measures not currently offered by Focus on Energy account for the remaining 3% of agricultural natural gas BAU achievable potential.

Table 58 also lists a few agricultural measures not currently offered by Focus on Energy that Cadmus found cost-effective with achievable potential. Electric water heater upgrades account for 7% of total agricultural electric achievable potential, while low energy spray applications account for 5% of total agricultural electric achievable potential. Agricultural measures not currently offered by Focus on Energy account for 12% of total agricultural electric achievable potential. The efficient greenhouse unit heaters measure accounts for 3% of total agricultural natural gas BAU achievable potential and is the only agricultural natural gas measure not currently offered by Focus on Energy that attained achievable potential.

The potential study revealed that several agricultural measures currently offered by Focus on Energy did not pass the cost-effectiveness screening. Hence, they do not offer achievable potential. These measures are efficient natural gas grain dryers, gas water heater upgrades, and triple polycarbonate glazing.

Nearly Cost-Effective Measures

For each measure in the potential study, Cadmus determined cost-effectiveness using the TRC test ratio then calculated a savings-weighted B/C ratio for each potential study measure across fuel savings types, construction vintages, sectors, and segments. A measure may prove cost-effective for some variables combinations and not cost-effective for others. Cadmus identified measures as nearly cost-effective where no iterations attained achievable potential (i.e., a TRC test ratio greater than or equal to 1.0), and at least one measure iteration attained a TRC test ratio between 0.7 and 1.0. Table 59 lists these measures, which may be of interest moving forward if product and market developments continue.

Table 59. Nearly Cost-Effective Potential Study Measures

Sector	Measure Group
Residential	Air to Air Heat Exchanger
	Cooking Range
	Door
	Drain Water Heat Recovery
	Dryer
	Indirect Water Heater
	Insulation—Basement
	Insulation—Ceiling
	Insulation—Rim And Band Joist
	Integrated Heat
	Water Heater Tank Wrap
Commercial and Government	Air to Air Heat Recovery
	Cooling Tower VSD Fan
	Dishwasher—Residential Sized
	Hotel Key Card Control System
	Ice Maker
	Reverse Cycle Chillers

Conclusions

Study Findings

Focus on Energy's savings potential under current program funding levels and policies remains relatively comparable to Focus on Energy's recent savings achievements. During the first four years of the study period (i.e., 2019–2022), Focus on Energy achieved electric potential savings of 2,468 GWh, compared to 2,235 GWh savings achieved from 2013 through 2016. Natural gas potential remains somewhat higher than recent achievement: savings potential from 2019–2022 is 114 million therms, compared to 87 million therms in program savings achieved from 2013–2016.

Under current Focus on Energy policies and funding levels, BAU achievable potential amounts to 0.80% in electric savings and 0.98% in gas savings. Absent significant changes in Focus on Energy's policies, funding, or market conditions, these BAU potential estimates can inform the program's savings goals for the 2019–2022 period. In determining these goals, the PSC should note that these estimates do not account for all program design constraints (e.g., net-to-gross rates), and further adjustments to these estimates likely will be appropriate to recognize such constraints and to set a goal that reflects program potential.

The full range of potential estimates generated in this study also indicates that total energy efficiency potential in the state, independent of Focus on Energy's current funding levels, can vary significantly under different program circumstances. For example, total achievable potential increases to 1.14% at increased incentive levels, and total economic potential represents 2.0% of total forecasted 2030 sales—an amount slightly greater than the 2.2% forecasted 12-year load growth.

Similar to the BAU scenario, these estimates do not account for all program design constraints. However, while total savings achievement would be generally reduced by several of those constraints, savings achievement in these scenarios could be increased by including measures not passing this study's measure-level cost-effectiveness screen.

The PSC only requires that Focus on Energy achieves cost-effectiveness for the overall residential and nonresidential portfolios, and such cost-effectiveness standards could be met with programs that, in addition to more cost-effective measures, include some measures that are not cost-effective. Screening measures for economic potential using a MTRC greater than or equal to 0.75 increases total economic electric and natural gas potential by 7.4% and 17.9%, respectively. Because this scenario, as modeled, still would likely meet Focus on Energy's requirement to maintain overall cost-effectiveness in its residential and nonresidential portfolios, it provides an estimate of the degree to which this factor could affect the difference between achievable potential presented here and program potential that could be achieved by Focus on Energy.

Cadmus' analysis identified a number of measures that offer significant cost-effective savings potential:

- Residential LED standard and specialty lighting

- Residential smart strip plug outlet
- Residential refrigerator recycling
- Residential Wi-Fi thermostats
- Nonresidential lighting and lighting controls
- Nonresidential HVAC controls

While most emerging technology measure iterations did not pass the cost-effectiveness screen, some iterations did (e.g., combinations of fuel savings types, construction vintages, building segments). For example, residential measures heat pump water heaters, cold climate heat pumps, and insulating concrete form construction attained some level of BAU achievable potential.

In addition to identifying those new measure considerations, Cadmus identified a number of initial program considerations for the residential and nonresidential sectors.

Residential Sector Considerations

Focus on Energy's residential portfolio offers the following:

- Energy assessments to identify savings opportunities in single-family and multifamily homes
- A comprehensive suite of prescriptive rebates
- Incentive levels targeting income-qualified participants
- Pilot programs targeting energy-efficient behavior

Table 60 details each program that Focus on Energy currently offers, along with the program's calendar year (CY) 2016 performance status, based on the CY 2016 Evaluation Report. Cadmus provides recommended actions from this report's findings, including a recommendation to add a behavioral energy feedback program to the portfolio offerings.

Table 60. Summary of Portfolio Plan Considerations

Program	Status	Eligibility	CY 2016 Performance	Action
Home Performance with ENERGY STAR	Existing	Retrofit, with increased incentives for income qualification of 80% or less of State Median Income	Met 96% of its goal for kWh savings and exceeded its kW and therms goals for both *ex ante* and verified gross savings	Continue program, consider adding energy feedback devices, Wi-Fi-enabled thermostat measures, and other measures with additional savings potential
New Homes	Existing	New construction	Exceeded goals for both *ex ante* and verified gross savings. However, net savings were very low due to evaluation findings that most new homes already were	Revise program to produce net savings (baseline study currently in progress)

Program	Status	Eligibility	CY 2016 Performance	Action
			built well above program baselines.	
Retailer Lighting and Appliance	Existing	All residential	Exceeded goals for *ex ante* gross energy savings, but the verified gross kWh achievement was slightly below goal	Continue program, adjusting baseline assumptions during quadrennium due to new ENERGY STAR lighting specifications and EISA backstop provision; consider appliance measures with additional savings potential, and upstream opportunities for new measures where available
Behavioral Energy Feedback	New	All residential	n/a	In addition to incorporation into the Home Performance Program, consider offering a program exclusively for behavior energy feedback devices to capture maximum savings
Simple Energy Efficiency	Existing	Existing residential	Met *ex ante* gross savings goals, but fell slightly short of its verified gross savings goals	Continue program, exploring additional measures options and ways to allow customers to opt-out of specific measures
Multifamily Energy Savings	Existing	All residential properties with four or more units	Met all of its CY 2016 *ex ante* savings goals but fell short of all verified gross savings goals	Continue program, expand cross-promotional opportunities with Multifamily Direct Install Program
Multifamily Direct Install	Existing	All residential properties with four or more units	Met all of its *ex ante* savings goals but fell short of all verified gross goals	Continue program, expand cross-promotional opportunities with Multifamily Energy Savings Program
Seasonal Savings	Pilot	Existing residential	Fell short of *ex ante* and verified gross goals	Consider implementing program with direct access to customer billing data
Retail Products Platform	Pilot	All residential	n/a	Consider implementing measure offerings through the Retailer Lighting and Appliance Program

[1] Cadmus did not verify savings or demand reduction for the Retail Products Platform Pilot Program in CY 2016.

[2] The Manufactured Homes Pilot was offered in CY 2015. The Pilot Implementer met its CY 2015 goals for *ex ante* savings, but it did not meet its CY 2015 goals for verified gross savings.

Conclusion: While LED measures currently offer savings, falling LED prices and changes to efficiency standards during the next quadrennium will impact the energy savings potential for LEDs.

Though the potential study found significant BAU achievable potential for general service (254,955 MWh) and specialty (374,858 MWh) LEDs, Focus on Energy must capture these savings quickly because, starting in 2020, currently assumed regulatory standards established by EISA change the effective baseline used to measure lighting savings. This change in the baseline will reduce available lighting savings by approximately 50% and affect lighting programs' overall cost-effectiveness.

Furthermore, LED prices continue to become cost competitive with baseline measures, and “value LEDs” compete with program-eligible LEDs for a share of the efficiency market. Therefore, an LED-focused lighting program that incorporates a high-impact delivery model and that can be deployed quickly would best serve Focus on Energy in capturing achievable savings in a short period of time.

- **Recommendation:** Due to implementation uncertainty regarding the EISA backstop provision, continue monitoring federal standard revisions with the potential expectation that standard and specialty LED lamps may need to be redesigned for the next Focus on Energy planning cycle.
- **Recommendation:** If the EISA backstop takes effect, consider adding direct-install elements to existing residential programs (e.g., through Home Performance with ENERGY STAR) to maximize savings before the standards increase.
- **Recommendation:** If the EISA backstop takes effect, consider launching a quick-start LED distribution program to capture savings prior to EISA’s effective date. Direct-install and giveaway programs can be launched with relative rapidity and can deliver savings results within a short time frame. Consider targeting nonprofit and educational organizations through turnkey programs with established, clear messages, offerings, and participation processes that can be easily understood. These programs also can incorporate other measures with energy savings potential (i.e., advanced power strips, water-saving devices) and serve a cross-promotional function by seeking to increase sales and awareness of energy efficient products, along with Focus on Energy’s other program offerings that reduce energy consumption.

Conclusion: Focus on Energy’s appliance recycling program can continue to thrive despite a volatile market.

Focus on Energy’s Appliance Recycling Program offers residential customers an incentive to have secondary, operational freezers and refrigerators picked up and recycled. Focus on Energy designed the program using many industry best practices, including the following:

- Partnering with an experienced, third-party appliance recycling vendor
- Offering step-by-step participation instructions
- Providing an incentive sufficiently high enough ($35) to motivate customer participation

Some utilities across the country have discontinued long-running appliance recycling programs because of decreasing cost-effectiveness as savings for recycled appliances decline (i.e., as appliance stock becomes more efficient) and avoided costs plummet. Despite market issues, the potential study indicated high achievable potential (BAU) for removing secondary refrigerators (402,905 MWh) and freezers (135,684 MWh) within Focus on Energy’s territory.

- **Recommendation:** In the next program cycle, continue to offer an Appliance Recycling Program as long as ongoing market research indicates that cost-effectiveness can be maintained.

Conclusion: Bundled measure packages and performance-based incentives and direct-install measures may allow Focus on Energy to capture savings from measures no longer deemed cost-effective.

The Home Performance with ENERGY STAR Program offers subsidized home energy audits as well as performance-based incentives for customers who install energy efficiency retrofits in single-family homes, with increased incentive levels for income-qualified customers. The program uses the following incentive tiers:

Tier 1
1. $850 for 10%–19% energy reduction
2. $1,250 for 20%–29% energy reduction
3. $2,000 for 30% energy reduction

Tier 2 (Income-Qualified)
1. $1,000 for 10%–19% energy reduction
2. $1,500 for 20%–29% energy reduction
3. $2,250 for 30% energy reduction

The performance-based incentive structure allows flexibility in individual measures implemented by customers as long as the projects achieve energy reductions over the home's audited baseline.

Cadmus' potential study shows individual weatherization measures (e.g., ceiling, slab, and rim joist insulation) no longer prove cost-effective. However, when bundled with other cost-effective measures, offered through a performance-based incentive, Focus on Energy may be able to continue realizing cost-effective savings from the program. Additionally, offering measure packages combined with direct-install offerings could help achieve project-level or program-level cost-effectiveness.

- **Recommendation:** Conduct additional analysis of bundled-measure and direct-installation scenarios during the planning process to determine whether the Home Performance with ENERGY STAR Program can continue to generate cost-effective savings for Focus on Energy. Based on these results, Focus on Energy should consider offering performance-based incentives for customers who implement cost-effective energy efficiency projects.
- **Recommendation:** Consider adding energy feedback measures to increase savings potential.

Conclusion: Measures commonly used in kit or direct-install programs account for a substantial portion of Focus on Energy's total residential achievable potential.

Focus on Energy's Simple Energy Efficiency Program offers measures—LEDs, showerheads, faucet aerators, advanced power strips and/or pipe insulation—at a minimum or no cost to residential customers. Focus on Energy's Multifamily Direct Install Program provides a similar measures via a direct-install offering to tenants of multifamily buildings.

The potential study found specialty and standard advanced LEDs account for over 25% of the total residential BAU achievable electric potential, while advanced power strips and hot water measures (i.e., aerators and showerheads) account for an additional 18% and 13%, respectively. Showerheads and aerators also account for 39% of the total BAU residential achievable gas potential. Simple Energy Efficiency and the Multifamily Direct Install programs will continue to achieve significant savings for Focus on Energy's residential portfolio in the next program cycle.

- **Recommendation:** Consider updating the Multifamily Direct Install Program measure offerings to include advanced power strips.

Conclusion: Residential connected load measures—smart thermostats and behavioral energy feedback—offer opportunities and substantial energy savings potential for Focus on Energy's residential portfolio.

Focus on Energy began exploring these opportunities by offering incentives for smart thermostats through a pilot program for retail purchases and a Seasonal Savings Program for Nest thermostat customers who agreed to specific operating adjustments. According to the potential study, smart thermostat and behavior energy feedback measures will offer substantial savings opportunities in the future, accounting for about 10% of total BAU residential achievable electric savings potential and over 34% of residential therms savings potential. Effective access to utility data is important for supporting connected load program operations and verifying savings; as a third-party administrator, Focus on Energy should seek to continue strengthening partnerships with utilities to obtain complete and timely data access.

- **Recommendation:** Continue the smart thermostat measure offering introduced in 2017 through the Home Performance with ENERGY STAR Program and monitor results during the next program cycle through continued analysis of billing data. To maximize savings from a smart home program, consider expanding the connected load measure offerings by adding a behavioral energy feedback component.
- **Recommendation:** Consider offering a program exclusively for smart thermostats and other energy-saving mechanisms that rely on feedback from metered data. An example of behavior programs found through the benchmarking analysis was the use of a home energy reports model offered by several implementers (such as Opower). Home energy report programs provide informational reports to homeowners based on usage and incentives for reducing use. Ensure the program effectively incorporates and promotes the online portal/tools offered by behavioral program implementers. These tools seek to further engage treatment customers in energy education and encourage greater behavior changes (and savings). Program administrators and evaluators also rely on billing data to develop reports and assess savings, so this effort would require partnerships with Wisconsin utilities.

Nonresidential Sector Considerations

In the nonresidential sector, Focus on Energy offers prescriptive and custom energy efficiency opportunities as well as technical support for facility audits and new building designs. Program Implementers assessed opportunities to deliver savings through energy management and peak pricing pilot programs.

Table 61 details each nonresidential program Focus on Energy currently offers, along with program's CY 2016 performance status, based on the CY 2016 Evaluation Report and recommended actions from this report's findings.

Table 61. Summary of Portfolio Nonresidential Considerations

Program	Status	Eligibility	CY 2016 Performance	Action
Agriculture, Schools and Government	Existing	Targeted customer groups with average monthly demand under 1,000 kW	Fell short of *ex ante* and verified gross goals, although contractual energy savings implementation targets were met per the Program Administrator when carryover savings were applied	Consider measures with additional savings potential
Business Incentive	Existing	All customer groups with average monthly demand under 1,000 kW	Exceeded verified gross and *ex ante* electric energy savings goal, but did not meet its gross and *ex ante* lifecycle demand reduction and therms savings goals	Consider measures with additional savings potential; consider midstream delivery opportunities for these customer groups where appropriate
Chain Stores and Franchises	Existing	Targeted customer groups with average monthly demand under 1,000 kW (integrated with Business Incentive Program beginning in 2017)	Exceeded verified gross and *ex ante* electric energy savings and demand reduction goals, but did not meet its gross and *ex ante* lifecycle therms savings goals	Consider measures with additional savings potential; assess midstream delivery opportunities for these customer groups where appropriate, including the CY 2017 commercial kitchen equipment pilot
Design Assistance	Existing	New construction or substantial renovations	Exceeded *ex ante* and verified electric energy savings goals, but fell short of *ex ante* and verified demand reduction and therms savings goals	Assess ways to target therm savings based on identified natural gas savings potential
Large Energy Users	Existing	All customer groups with average monthly demand exceeding 1,000 kW or 100,000 therms	Exceeded *ex ante* and verified therms savings goals, but fell short of *ex ante* and verified demand reduction and electric savings goals	Consider targeting specific industrial customer segments based on identified savings potential
Small Business	Existing	Targeted customer groups with average monthly demand under 100 kW	Exceeded *ex ante* and verified electric savings and demand goals, but fell short of *ex ante* and verified demand reduction and therms savings goals	Consider measures with additional savings potential

Program	Status	Eligibility	CY 2016 Performance	Action
Strategic Energy Management	Pilot	All customer groups with average monthly demand exceeding 1,000 kW or 100,000 therms	n/a[1]	Review program design and customer targeting to ensure program can be implemented cost-effectively
On Demand Savings	Pilot	Select commercial and industrial customers	n/a[1]	Pilot completed in CY 2016

[1] Cadmus did not verify savings or demand reduction for the Strategic Energy Management and On Demand Savings Pilot Programs in CY 2016.

Conclusion: As currently designed, the nonresidential programs capture most achievable potential, but some current program measures no longer remain cost-effective.

According to the potential study, measures incented by the Focus on Energy's nonresidential programs account for 82% of the portfolio's total commercial and government achievable electric potential and 78% of the total commercial and government achievable gas potential. The portfolio's lighting measures account for 42% of the total BAU achievable electric potential, variable speed pump and fan measures account for 7%, and direct digital control and smart thermostats for HVAC systems account for 20% and 16% of the total BAU achievable therm savings potential, respectively. While most measures incented by the program remain cost-effective, some do not (e.g., cooling tower VSD fans, demand control defrost, air-to-air heat recovery, strategic energy management for commercial and government segments), calling for updates to the program's measure offerings.

- **Recommendation:** Consider discontinuing nonresidential program incentives for measures no longer deemed cost-effective, or bundling measures that nearly proved cost-effective. For example, Focus on Energy could require coupling guest room energy management incentives with other building upgrades, such as package terminal air conditioner (PTAC) units or other in-room measures.

Conclusion: The nonresidential programs could capture additional achievable savings potential with limited modifications.

Although, as discussed, Focus on Energy's nonresidential program's design sought to capture savings from a diverse range of measures, the potential study identified 12 measures with notable achievable potential but which are not currently offered by Focus on Energy programs.

- **Recommendation:** Incorporate measures offering savings potential but not currently deployed in the nonresidential programs. Where feasible, deliver new measures through the prescriptive incentive design to limit participation barriers.
- **Recommendation:** Consider using a midstream incentive approach for LED lamps, troffers, and downlight kits, with fail-safes that allow program staff to monitor participation activity. Cadmus benchmarking review found a few strategies regarding how other utilities mitigate midstream

program oversubscription. Xcel Energy requires its midstream customers to contribute at least $2.00 per lamp or kit; and ComEd requires midstream participants to pay at least 50% of the incentive value per unit. ComEd also requires program distributors to forecast sales 30 to 90 days out, so the utility can estimate funding needs and sets funding limits for each participating distributor. Both utilities incorporate eligibility and customer data requirements to ensure installations occur within their jurisdictions.

- **Recommendation:** Tailor recommissioning marketing messages to target customer segments more likely to result in cost-effective projects (i.e., office and retail).

Comparisons to Similar Studies

Cadmus compiled results from 12 electric and nine gas energy efficiency potential studies completed during the last four years. In comparing these studies' results, many factors should be considered that affect the results. These include (but are not limited to) the following:

- The mix and vintage of sectors and segments
- Fuel-use patterns
- Energy-management practices
- Certain variations in analytic methods (i.e., the method used to account for local/national codes and standards)

Therefore, results derived from comparing this study with others should be considered indicative rather than conclusive.

Moreover, comparisons with other studies can be especially difficult for economic and achievable potential, given that these estimates depend on variables such as avoided costs and local market conditions. These estimates may differ significantly across utilities, resulting in spurious conclusions if not taken into consideration when making comparisons. For example, holding all else constant, a utility with higher avoided costs will likely produce higher estimates of economic potential, given that more measures will prove cost-effective for the utility (relative to a utility with low avoided costs). Figure 29 shows electric achievable potential as a percentage of baseline sales.

For comparison purposes, Cadmus chose, where possible, for the base achievable to represent the "realistic" achievable rather than the max achievable. The figure illustrates that the reviewed studies showed estimated electric achievable potentials ranging from 6% to 24% (averaging 12%), compared to Focus on Energy's BAU achievable potential of 9%. As many of the other studies did not limit potential calculations based on available funding or incentive levels, their results may more directly compare to Focus on Energy's total achievable low and moderate scenarios, totaling 9% and 13%, respectively.

As these studies vary by time frames (ranging from 10 to 20 years), another perspective arises from comparing the average annual savings rate of realistic achievable potential. Of the 12 studies, average annual savings ranged from 0.3% to 2.1%, with an average of 0.8%. Cadmus compared these to Focus on Energy's BAU average annual savings rate of 0.8% and max achievable potential's annual savings rate of 1.2%.For additional context, the average annual savings rate was 0.8% and 1.1% represented Focus on Energy's low and moderate achievable potential, respectively.

Figure 29. Realistic Achievable Potential as Percentage of Baseline Electricity Sales

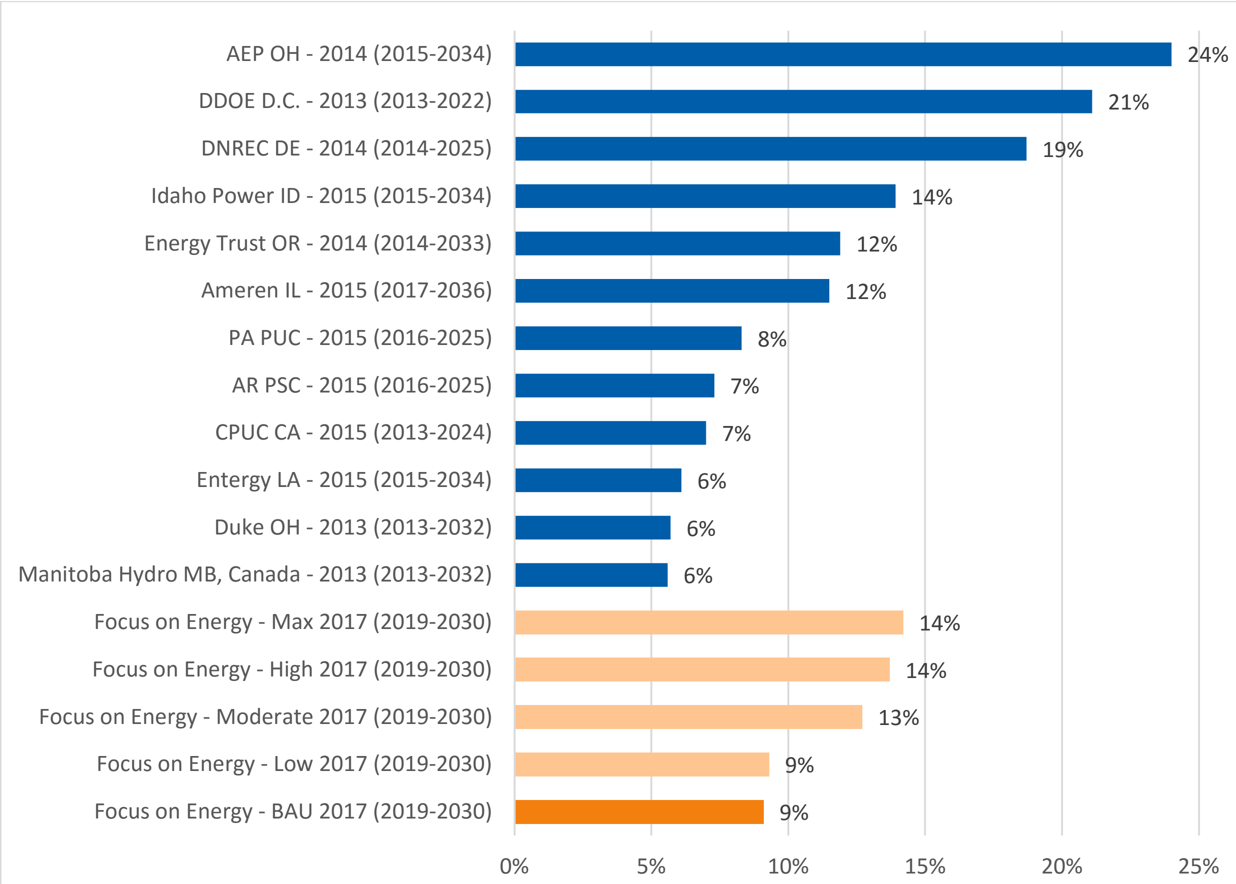
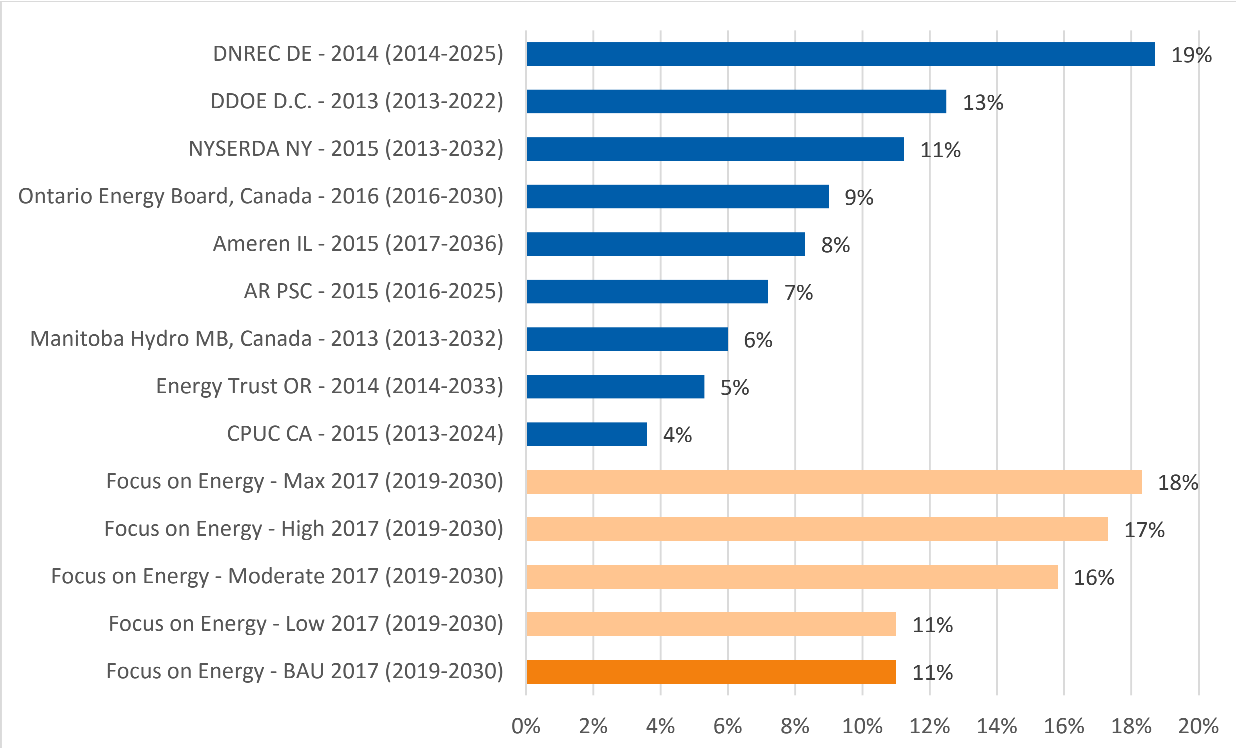


Figure 30 shows realistic gas achievable potential as a percentage of baseline sales for this study. The reviewed studies show estimated achievable potentials ranging from 4% to 19% (and averaging 9%), compared to Focus on Energy's BAU achievable potential of 11%, total low achievable potential of 11%, and total moderate achievable potential of 16%. Another perspective can be attained by comparing the average annual savings rate for the realistic achievable potential. Of the nine studies, average annual savings ranged from 0.3% to 1.9%, with an average of 0.7%. This compares to Focus on Energy's BAU average annual savings rate of 0.9% and to the max achievable potential average annual savings rate of 1.5%. Focus on Energy low and moderate average annual savings rate was 0.9% and 1.3%, respectively.

Several factors likely contribute to the finding that natural gas savings potential is estimated as higher for Focus on Energy than for most of the other jurisdictions listed in Figure 30. For example, a smaller share of customers in some states use natural gas for heating fuel instead of alternatives such as propane and heating oil. In addition, the avoided costs of natural gas usage vary based on state conditions and policies, and use of lower avoided costs will identify less economic and achievable potential.

Figure 30. Realistic Achievable Potential as Percentage of Baseline Natural Gas Sales



Analysis Methodology

Developing Baseline Forecasts

Collecting Baseline Data

Creating a baseline forecast required multiple data inputs to accurately characterize energy consumption within Focus on Energy's service area. These key inputs included the following:

- Participating utility sales and customer forecasts
- Major customer segments (e.g., residential dwelling types, commercial business types)
- End-use saturations (the percentage of an end-use [e.g., air conditioner] present in a building)
- Equipment saturations (e.g., average number of units in a building)
- Fuel shares (proportion of units using electricity versus natural gas)
- Efficiency shares (the percentage of equipment below, at, and above standard)
- Annual end-use consumption estimates by efficiency levels

Data specific to Focus on Energy's service territory not only provided the basis for baseline calibration but also supported estimation of technical potential. The assessment included a significant primary data collection effort to ensure use of the best available data.

Table 62 identifies the key data sources used.

Table 62. Baseline Forecast Data Sources

Data	Residential Single-Family and Multifamily	Commercial and Government	Industrial	Agricultural
Baseline Sales and Customers	Wisconsin Utilities Customer Databases, Actual	Wisconsin Utilities Customer Databases, Actual	Wisconsin Utilities Customer Databases, Actual	Wisconsin Utilities Customer Databases, Actual
Forecasted Sales and Customers	Wisconsin Utilities Forecasts	Wisconsin Utilities Forecasts	Wisconsin Utilities Forecasts	Wisconsin Utilities Forecasts
Percentage of Sales by Building Type	Wisconsin Utilities Customer Databases	Wisconsin Utilities Customer Databases	Wisconsin Utilities Customer Databases	Wisconsin Utilities Customer Databases
End-Use Energy Consumption	Wisconsin Utilities Load Forecasts, Primary Research, EIA Residential Energy Consumption Survey (RECS), ENERGY STAR, Wisconsin Focus on Energy 2016 TRM	Wisconsin Utilities Load Forecasts, Primary Research, EIA Commercial Building Energy Consumption Survey (CBECS), ENERGY STAR, Wisconsin Focus on Energy 2016 TRM	Wisconsin Utilities Load Forecasts, Primary Research, EIA Manufacturing Energy Consumption Survey (MECS), Wisconsin Focus on Energy 2016 TRM	Wisconsin Utilities Load Forecasts, Primary Research, Cadmus Research, Wisconsin Focus on Energy 2016 TRM
Saturations and Fuel Shares	Primary Data Collection Phone Survey and Site Visit, Wisconsin Focus on Energy Program Evaluations, EIA RECS	Primary Data Collection Phone Survey and Site Visit, Wisconsin Focus on Energy Program Evaluations, EIA's CBECS	Primary Data Collection Phone Survey and Site Visit, Industrial Assessment Center, EIA's MECS, Cadmus Research	Primary Data Collection Phone Survey and Site Visit, Cadmus Research
Efficiency Shares	Primary Data Collection Phone Survey and Site Visit EIA's RECS, ENERGY STAR unit shipment reports	Primary Data Collection Phone Survey and Site Visit, Wisconsin Focus on Energy Program Evaluations, EIA's CBECS	Primary Data Collection Phone Survey and Site Visit, Industrial Assessment Center, EIA's MECS, Cadmus Research	Primary Data Collection Phone Survey and Site Visit, Cadmus Research

Baseline Forecast of Sales and Customers

Cadmus requested customer counts, sales (consumption), and peak demand by sector and segment, where available from Focus on Energy participating utilities. The initial data request included additional details including these:

- The number of customers and weather-normalized actual electric and natural gas sales for a historic period (i.e., 2015)—to serve as a base year)—and a forecast period.
- Forecast sales should be absent energy efficiency to avoid double-counting savings.
- These customer data were intended to represent the number of buildings or dwellings but accounts and premises were used as a proxy where available and necessary.
- Utility forecasts should only reflect customers in Wisconsin

The following Focus on Energy participating utilities provided data on actual and forecasted sales and on customers by sector:

- Madison Gas and Electric
- WE Energies
- WPPI Energy
- Xcel Energy
- Manitowoc Public Utilities
- Wisconsin Power and Light
- Wisconsin Public Service

Once Cadmus received all the customer counts and sales from the base year, it compared the information to the US EIA Form 861 and 176 data for reasonableness and adjusted the sales and customer forecasts for the remaining share of Focus on Energy participating utilities from whom no data was received. After making these adjustments, Cadmus calibrated each sector and fuel type model to match the segmented utility load and sales forecasts. Prior to estimating technical potential, Cadmus adjusted the load and sales forecasts to account for future federal standards to avoid double-counting the savings from these end uses.

End-Use Energy Consumption

The per-unit end-use energy consumption—sometimes called unit energy consumption for a residential forecast and energy-use intensity for a commercial forecast—provides a crucial input for end-use forecasts. Industry studies have derived this consumption using a variety of methods, including statistical methods (e.g., conditional demand modeling); physics-based building simulation models (e.g., the U.S. Department of Energy's EnergyPlus model); and simple algorithms (e.g., ENERGY STAR calculators).

Cadmus drew from several resources to estimate the end-use energy consumption for each sector, segment, and fuel type combination in the study. We prioritized using data from primary research—either site visits or phone surveys—before relying on secondary data sources. Using primary data from Wisconsin data sources allowed for better baseline energy use estimates and ensured that results are based upon local data sources, where possible. Using local data sources improves the potential savings estimates compared with relying on regional or national data for end-use energy consumption values.

Saturations and Fuel Shares

To produce a bottom-up, end-use forecast, Cadmus first determined how many units of each end use would be found in a typical home. End-use saturations represent the average number of units in a home, and fuel shares represent the proportion of those units using electricity versus natural gas. For instance, on average, a typical home has 0.9 clothes dryers (the saturation), and 85% of these units are electric (the fuel share).[14]

Efficiency Shares

Efficiency shares equal the current saturation of a specific type of equipment (of varying efficiency). Within an end use, these shares sum to 100%. For instance, the efficiency shares for a central air conditioning end use may be 50% SEER 13, 25% SEER 15, and 25% SEER 16.

End-use Consumption Estimates

Prior to estimating the technical potential of electric and natural gas energy efficiency measures, Cadmus developed annual end-use consumption estimates for each fuel type, sector, and segment. The equation below specified the forecast for each end use in the study:

$$EUSE_{ij} = \Sigma_{e} ACCTS_{i} * UPA_{i} * SAT_{ij} * FSH_{ij} * ESH_{ije} * EUI_{ije}$$

Where:

EUSEij	=	Total energy consumption for end use j in customer segment i
ACCTSi	=	The number of accounts/customers in segment i
UPAi	=	The units per account in customer segment i
SATij	=	The share of customers in customer segment I with end use j
FSHij	=	The share associated with electric or natural gas in end use j in customer segment i
ESHije	=	The market share of efficiency level e in the equipment for customer segment ij
EUIije	=	End-use intensity or unit energy consumption for the equipment configuration ije

Each end-use forecast was summed within each segment, sector, and fuel type combination to determine the overall sales forecast. Appendix A. Baseline Data contains detailed base case forecasts for each end use, segment, sector, and fuel type combination in the study.

Measure Characterization

Cadmus developed a comprehensive measure database of technical and market data that applied to all end uses in various market segments, and estimated costs, savings, and applicability for a comprehensive set of energy efficiency measures. Through this process, measure savings are calculated as a unit energy savings or measure percentage savings to estimate the end-use present savings. These measure end-use percentage savings, when applied to the baseline end-use forecast, produced

14 Saturations are less than 1.0 when some homes do not have the end use.

estimates of energy efficiency potential. First, Cadmus developed an initial list of measures, with its database including the following:

- Measures included within the Wisconsin Focus on Energy's 2016 TRM
- Measures currently included in the Focus on Energy's prescriptive programs and selective SPECTRUM custom measures
- Efficiency tiers from the Consortium for Energy Efficiency and ENERGY STAR
- Measures from Cadmus' extensive database, including measures in regional or national databases (e.g., California Database for Energy Efficient Resources [DEER])[15] and TRMs
- Selected emerging technologies and behavioral measures

Residential emerging technologies examined in this study included the following:

- Residential behavioral measures
- Heat pump dryers
- Cool climate heat pumps
- Geothermal heat pump water heaters
- Specialty framing (insulating concrete forms/structural insulated panels)
- CO_2 heat pump water heaters

Nonresidential emerging technologies included the following:

- Natural gas dryers with modulating controls
- Boiler oxygen trim controls
- Natural ventilation designs for new construction
- Continuous commissioning
- Advanced lighting and controls design
- Automated fault detection and diagnostics for rooftop units
- Variable refrigerant flow systems
- Active chilled beam cooling systems

Cadmus focused on emerging technologies approaching commercialization or that may become cost-effective within the next five years. In doing so, Cadmus conducted a qualitative screen to evaluate the applicability of measures to Wisconsin. This involved reviewing and excluding measures from analysis if they met the following conditions:

- Not commercially available
- Did not benefit participating utilities' systems

[15] California Energy Commission Database for Energy Efficient Resources. http://www.energy.ca.gov/deer/

- Were unrealistically expensive to install
- Fell below prevailing code or standard practices.

Some measures passing the initial qualitative screen were later eliminated if reliable data on savings or costs proved unavailable. Measures removed from the initial measures list due to unreliable and limited data included the following:

- Demand monitoring kiosks
- Display case economizer
- Robotic milking systems
- Milk pasteurization systems

While current research could not justify including these technologies in this study, Focus on Energy programs may want to consider reevaluating these technologies in future studies and assessing whether their market viability or supporting data has improved.

Upon identifying measures, Cadmus compiled all inputs required to estimate potential. Table 63 shows key inputs and possible data sources. Primary data collected from site visits and surveys were designed to collect information on key measures, and data was supplemented for other measures by the other sources.

Table 63. Key Measure Data Sources

Input	Residential Single-Family and Multifamily	Commercial and Government	Industrial	Agricultural
Energy Savings	Primary Data Collection Phone Survey and Site Visit, Wisconsin Focus on Energy Program Evaluations, Wisconsin Focus on Energy 2016 TRM, ENERGY STAR, U.S. Department of Energy (DOE)/EERE,[1] Regional Technical Forum, Cadmus research	Primary Data Collection Phone Survey and Site Visit, Wisconsin Focus on Energy Program Evaluations, Wisconsin Focus on Energy 2016 TRM, CBECS 2013 Microdata, ENERGY STAR, DEER, DOE/EERE, Regional Technical Forum, Cadmus research	Primary Data Collection Phone Survey and Site Visit, Wisconsin Focus on Energy Program Evaluations, Wisconsin Focus on Energy 2016 TRM, DOE's Industrial Assessment Center Database, Industrial Savings Potential Project (ISPP), Industrial Council data, Cadmus research	Primary Data Collection Phone Survey and Site Visit, Wisconsin Focus on Energy Program Evaluations, Wisconsin Focus on Energy 2016 TRM, Regional Technical Forum, Cadmus research
Equipment and Labor Costs	Wisconsin Focus on Energy 2016 TRM, Wisconsin Focus on Energy Program Evaluations, National Residential Efficiency Measures Database,[2] RSMeans,[3] ENERGY STAR, DOE/ Energy Office of Energy Efficiency (EERE), DEER, Regional Technical Forum, Incremental Cost Studies, Online retailers, Cadmus research, SPECTRUM cost data	Wisconsin Focus on Energy 2016 TRM, Wisconsin Focus on Energy Program Evaluations, RSMeans, ENERGY STAR, DOE/EERE, DEER, Regional Technical Forum, Incremental Cost Studies, online retailers, Cadmus research, SPECTRUM cost data	Wisconsin Focus on Energy 2016 TRM, Wisconsin Focus on Energy Program Evaluations, DOE's IAC Database, ISPP, Council data, Cadmus research, SPECTRUM cost data	Wisconsin Focus on Energy 2016 TRM, Wisconsin Focus on Energy Program Evaluations, RSMeans, ENERGY STAR, DOE/EERE, DEER, Regional Technical Forum, Incremental Cost Studies, online retailers, Cadmus research, SPECTRUM cost data
Measure Life	Wisconsin Focus on Energy 2016 TRM, Wisconsin Focus on Energy Program Evaluations, ENERGY STAR, DEER, Cadmus research	Wisconsin Focus on Energy 2016 TRM, Wisconsin Focus on Energy Program Evaluations, ENERGY STAR, DEER, Cadmus research	Wisconsin Focus on Energy 2016 TRM, Wisconsin Focus on Energy Program Evaluations, DOE's Industrial Technologies Program, DEER, Council data, Cadmus research	Wisconsin Focus on Energy 2016 TRM, Wisconsin Focus on Energy Program Evaluations, ENERGY STAR, DEER, Cadmus research
Technical Feasibility	Primary Data Collection Phone Survey and Site Visit, Cadmus research	Primary Data Collection Phone Survey and Site Visit, Cadmus research	Primary Data Collection Phone Survey and Site Visit, Wisconsin Focus on Energy Program Evaluations, Council data, Cadmus research	Primary Data Collection Phone Survey and Site Visit, Cadmus research
Percentage Incomplete	Primary Data Collection Phone Survey and Site Visit, Wisconsin Focus on Energy Program Accomplishments, RECS, Cadmus research	Primary Data Collection Phone Survey and Site Visit, Wisconsin Focus on Energy Program Accomplishments, Cadmus research	Primary Data Collection Phone Survey and Site Visit, Wisconsin Focus on Energy Program Accomplishments, Cadmus research	Primary Data Collection Phone Survey and Site Visit, Wisconsin Focus on Energy Program Accomplishments, Cadmus research

[1] Department of Energy Office of Energy Efficiency and Renewable Technology (EERE). http://energy.gov/eere/office-energy-efficiency-renewable-energy

[2] National Renewable Energy Laboratory National Residential Efficiency Measures Database. http://www.nrel.gov/ap/retrofits/

[3] RSMeans Cost Data. https://www.rsmeans.com/products/online.aspx

Energy Savings and Measure Interactions

For each energy efficiency measure, Cadmus had to estimate energy savings, both as savings per unit (kWh or therm) and as savings as a percentage of end-use consumption. These estimates also had to account for savings interactions and results across end uses (e.g., upon installing efficient lighting, cooling loads decrease due to the reduction of waste heat). Cadmus relied on a number of sources to develop savings estimates:

- **Primary Data Collection Phone Survey and Site Visit:** The primary data collection involved site visits and phone surveys in the residential, commercial, agriculture, and industrial sectors. Primary data provided comprehensive information on building characteristics, energy-consuming end uses, and equipment efficiencies as well as information on customers' attitudes towards energy efficiency and willingness to adopt efficiency measures.
- **Wisconsin Focus on Energy's most recent program evaluations and program data:** Program evaluations can inform estimates of energy savings, and many program evaluations use engineering algorithms (such as those found in TRMs), metering data, billing analyses, or building simulations to estimate savings for energy efficiency measures. These included any program data from implementation contractors (e.g., reports, work papers, impact calculations).
- **The Wisconsin Focus on Energy 2016 TRM:** The TRM was used as the primary method to calculate the estimate per-unit energy savings for a variety of measures. Cadmus supplemented default TRM values with primary data collection values where possible.
- **Other utility program evaluations:** Cadmus relied on other utilities' program evaluations when characterizing measures that Wisconsin Focus on Energy did not offer through its existing prescriptive programs. For some measures, Cadmus used an average value derived from multiple program evaluations. For example, Cadmus typically assumed that Home Energy Reports saved approximately 1.5% of a home's annual energy use, which Cadmus derived from a meta-analysis of Home Energy Report impact evaluations.
- **The U.S. Department of Energy (DOE) Uniform Methods Project or other standard evaluation protocols:** DOE's Uniform Methods Project defined standard calculations used to estimate energy savings for a number of measures. Cadmus' savings calculations were consistent with such industry standards.
- **ENERGY STAR Calculators:** U.S. Environmental Protection Agency's (EPA) ENERGY STAR calculators provided estimates of per-unit savings for a number of measures, including efficient appliances (e.g., refrigerators, freezers, clothes washers) and efficient home electronics (e.g., televisions, computers, monitors).
- **DOE/Energy Office of Energy Efficiency (EERE) technical support documents:** DOE included estimates of equipment energy consumption in its technical support documents for a number of different types of energy-efficient equipment.

Equipment and Labor Costs

Cadmus estimated equipment and labor costs for each energy efficiency measure and used these costs to calculate B/C ratios and to estimate potential program expenditures. Cadmus relied on a number of sources in developing cost estimates:

- **The Wisconsin Focus on Energy 2016 TRM:** The TRM provided estimates of per-unit costs for a variety of measures as part of the incremental cost database. Where possible, Cadmus supplemented default TRM values with primary data collection values. In some cases, secondary data were used due to differences in measure definitions between the TRM and the potential study.
- **Wisconsin Focus on Energy's most recent program evaluations and program data:** Where applicable, Cadmus used Focus on Energy equipment cost data from program data.
- **National Renewable Energy Laboratory (NREL) National Residential Efficiency Measures Database:** NREL maintains a detailed, up-to-date dataset of measure costs for a number of energy efficiency measures.
- **RSMeans:** RSMeans provided construction cost data, including costs for a number of home retrofits (e.g., weatherization, windows, other shell upgrades). Cadmus used data from 2016 RSMeans, the most recent version.
- **ENERGY STAR:** EPA provided current equipment costs for a number of ENERGY STAR-rated units.
- **DOE/EERE technical support documents:** DOE included estimates of equipment and labor costs in its technical support documents for a number of different types of energy-efficient equipment.
- **Incremental cost studies:** TRMs often require incremental cost studies that show baseline and efficiency measure costs (e.g., labor, equipment, O&M) and states often frequently update these studies to incorporate the most recent cost data. These studies included the measures most commonly offered through utility-sponsored energy efficiency programs.
- **Online retailers:** Cadmus staff continuously reviewed prices listed on manufacturer or retailer websites. While online retailers may not provide estimates of installation (labor) or annual O&M costs, they provide reliable equipment costs.
- **Focus on Energy SPECTRUM cost data:** The database contained project costs, mainly for custom projects and measures. Most data represented full costs within the database and could only be used for certain measures.

Measure Life

Cadmus used estimates of each measure's effective useful life (EUL) to calculate the lifetime NPV benefits and costs for each energy efficiency measure. Many data sources for measure savings and costs (described above) also provided estimates for measure lifetimes.

Cadmus relied on a number of sources to develop measure life estimates:

- The Wisconsin Focus on Energy 2016 TRM, which includes the results of a comprehensive review conducted by Cadmus in 2015 of measure lifetimes for all active Focus measures
- NREL's National Residential Efficiency Measures Database
- EUL Studies, including the Northeast Energy Efficiency Partnership's 2007 EUL study or EULs derived by the Association of Home Appliance Manufacturers[16]
- ENERGY STAR
- DOE/EERE technical support documents
- Regional TRMs

Technical Feasibility

Technical feasibility factors represented the percentage of homes or buildings that could feasibly install an energy efficiency measure. Technical limitations included equipment capability or space limitations. For example, solar water heaters could not be feasibly installed in all buildings, given some buildings did not have the required roof orientation and pitch. Cadmus relied on a number of sources to develop feasibility estimates:

- **Primary data collection phone survey and site visit:** These phone surveys and site visits included building characteristics that could inform estimates of technical feasibility. For instance, some water heaters located in small spaces reduced the feasibility of installing a heat pump water heater, which would require airflow above that of a standard water heater.
- **Stock assessments and surveys (e.g., EIA's RECS and CBECS):** These assessments included building characteristics that could inform estimates of technical feasibility. For instance, some floor insulation measures required a basement or a crawlspace; using EIA's RECS, Cadmus could determine the proportion of homes with a basement or crawlspace and which could, therefore, feasibly install this measure.
- **Energy efficiency program evaluations:** Some energy efficiency program evaluations included research to identify technical barriers to installing energy efficiency measures.
- **Council Power Plans and other potential studies:** Regional potential studies, such as the Council's Sixth and Seventh Power Plans,[17] provided estimates of the technical feasibility for common energy efficiency measures.

---

[16] Northwest Energy Efficiency Partnerships. "NEEP Load Shape Research and Data." Available online: http://www.neep.org/initiatives/emv-forum/forum-products#Loadshape Research and Data Catalog/

[17] Northwest Power Planning Council. "Power Planning." Available online: https://www.nwcouncil.org/energy/powerplan

- **Cadmus research; third-party research (including the Federal Energy Management Program, DOE, or Toolbase.org):** Various third-party measure characterization reports identified technical limitations for energy efficiency measures. Cadmus used these assessments to estimate the proportion of homes or businesses that could feasibly install each measure. In some instances, Cadmus' engineering judgment was used to proximate technical constraints.

Percentage Incomplete

Percentage incomplete factors represent the percentage of remaining homes or businesses yet to install an energy efficiency measure. This equals one minus the current saturation of energy efficiency measures. As the study had to account for Wisconsin Focus on Energy's program accomplishments, building energy codes and standards, and the natural adoption of efficiency measures, Cadmus relied on a number of sources to develop percentage incomplete estimates:

- Primary data collection phone survey and site visit for key measures
- Wisconsin Focus on Energy's most recent program evaluations and program data
- Recent stock assessments and surveys (e.g., U.S. EIA's RECS and CBECS)
- ENERGY STAR reports
- DOE/EERE technical support documents

Compiling Energy Efficiency Technology Measure Database

After creating a list of electric and gas energy efficiency measures applicable to Focus on Energy's service territory, Cadmus classified energy efficiency measures into two categories:

1. **High-efficiency equipment measures:** These measures directly affected end-use equipment (e.g., high-efficiency central air conditioners) that followed normal replacement patterns and were based on EULs.
2. **Non-equipment measures (retrofit):** These measures affected end-use consumption without replacing end-use equipment (e.g., insulation). As such measures did not include timing constraints from equipment turnover (except for new construction), they should be considered discretionary (i.e., savings could be acquired at any point over the planning horizon).

This study assumed all high-efficiency equipment measures would be installed at the end of the existing equipment's remaining useful life, hence Cadmus did not assess energy efficiency potential for early replacement.

Most measures naturally turn over within the study horizon, and long-run technical potential from early replacement measures equals savings from replace-on-burnout measures. However, early replacement measure costs are much higher than replace-on-burnout measure costs because the former reflect the full measure cost, not incremental costs. The economic potential, therefore, depends on the allocation of early replacement and replace-on-burnout measures. Including these early replacement measures would contribute to estimates of technical and economic potential inconsistent with their definitions.[18]

Early replacement, however, could be considered in estimating program potential. Short-run savings from early replacement measures could exceed savings from replace-on-burnout iterations as early replacement savings would be calculated using a below-standard baseline. Because this study did not include program potential, Cadmus excluded early replacement measures from analysis.

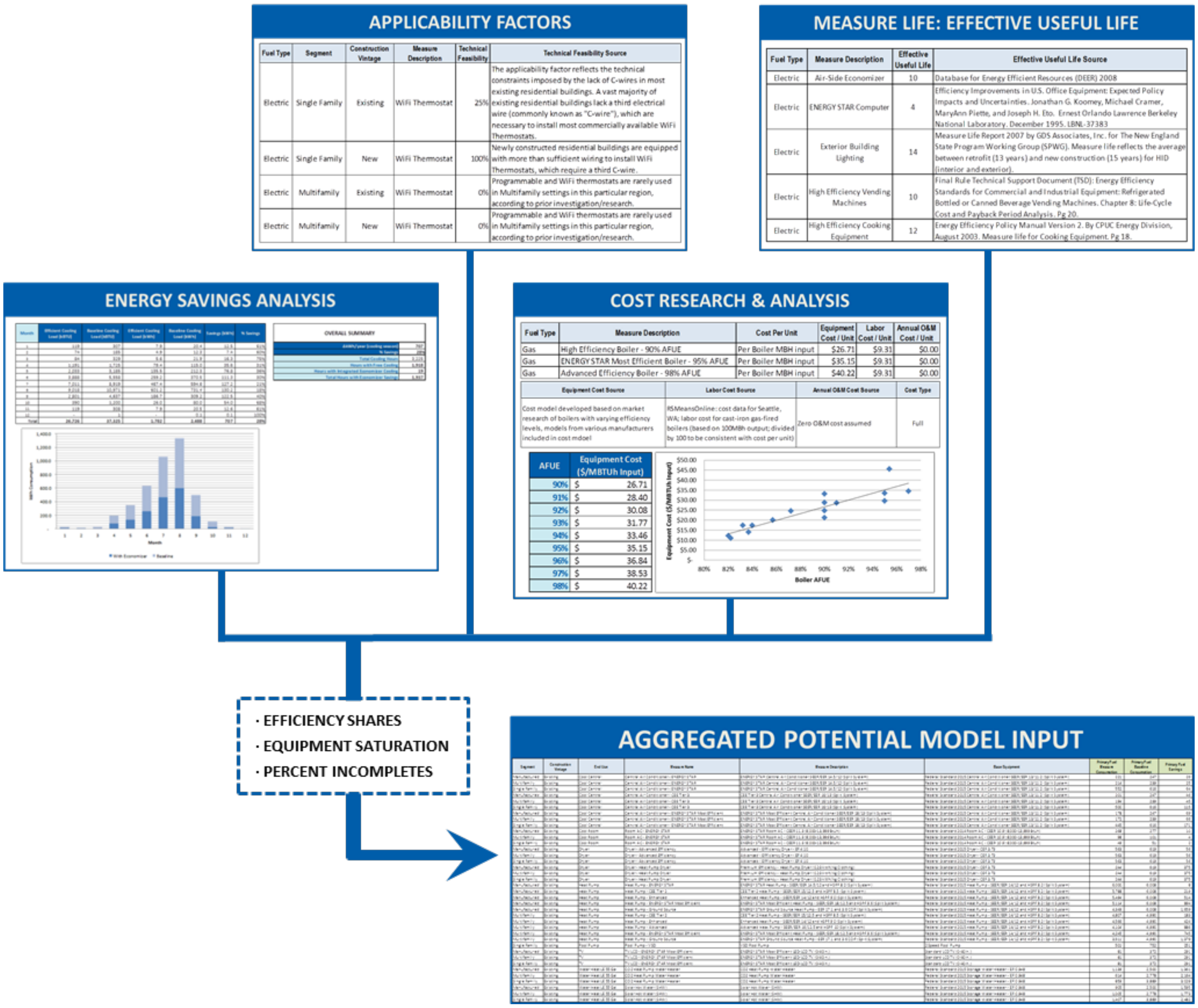
The following lists relevant inputs for each measure type:

- Equipment and non-equipment measures:
  - Technical feasibility—the percentage of buildings where customers could install this measure, accounting for physical constraints
  - Energy savings—average annual savings attributable to installing the measure, in absolute and/or percentage terms
  - Equipment cost—full or incremental, depending on the nature of the measure and the application
  - Labor cost—the expense of installing the measure, accounting for differences in labor rates by region, urban versus rural areas, and other variables
  - Measure life—the expected life of the measure's equipment
- Non-equipment measures only:
  - Percentage incomplete—the percentage of buildings where customers had not installed the measure, but where, technically, it could be feasibly installed
  - Measure competition—for mutually exclusive measures, accounting for the percentage of each measure likely installed (to avoid double-counting savings (e.g., 1.5 GPM and 2.0 GPM showerheads cannot both be installed in the same showerhead socket; therefore, only one permutation could possibly be installed depending on technical feasibility for technical potential and technical feasibility and cost-effectiveness for economic potential)

Underlying measure assumptions and analysis were characterized in Excel workbooks (by measure), as shown in Figure 31. The measure workbooks contained detailed saving calculations, cost research, EUL data, applicability factor values, and measure assumptions as well as well-documented source descriptions. Cadmus aggregated all measure data into a final master input file for use in the potential model.

[18] Cadmus considered refrigerator, freezer, and room air conditioner recycling to estimate savings associated with the removal of below-standard secondary units. These measures, however, could not be considered "early replacement" as they did not assume secondary units would be replaced with efficient units.

Figure 31. Example of Measure Technical Workbooks



Incorporating Codes and Standards

Cadmus' assessment accounted for changes in codes and standards over the planning horizon. These changes affected customers' energy-consumption patterns and behaviors and determined which energy efficiency measures would continue to produce energy savings over minimum requirements. Cadmus captured current efficiency requirements, including those enacted but not yet in effect. After receiving stakeholder feedback on the Wisconsin's energy code regulatory process and the most likely state codes enacted at the time of the Focus on Energy's next energy efficiency Quad Plan (2019–2022), Cadmus used Wisconsin's Uniform Dwelling Code SPS 320-325 for the residential sectors and the International Energy Conservation Code, 2015 edition, for commercial and government sectors.[19] Understanding this

[19] Wisconsin's commercial energy code currently bears the greatest resemblance to the International Energy Conservation Code, 2009 edition (Wisconsin's Commercial Building Code SPS 361-366).

uncertainty, Cadmus evaluated impacts associated to state building energy codes as part the scenario analysis provided in Appendix D.

Cadmus did not, however, attempt to predict how federal standards might change in the future. Rather, the study only factored in legislation already enacted—notably, EISA provisions slated to take effect over the course of analysis.

EISA requires that general service lighting becomes approximately 30% more efficient than current incandescent technology, with standards phased in by wattage from 2012 to 2014. In addition, EISA includes a backstop provision that requires even higher-efficiency technologies, beginning in 2020 (i.e., 45 lumens per watt or better). On January 18, 2017, the DOE's Final Rules on General Service Lamps expanded EISA requirements for previously exempt specialty lamps (e.g., reflectors, globes, candelabras) and higher lumen-standard lamps (greater than 2,600 lumens).

Although the 2020 backstop provision now includes these lamp types, uncertainty remains regarding how this standard will be implemented due to pending legal challenges. For this study, Cadmus assumed standard and specialty lamps would be impacted by the EISA backstop provision in 2020, and thus used a baseline of 45 lumen per watt lighting, starting in 2020, as the base case. Appendix D provides additional EISA lighting scenario analysis related to this standard.

Cadmus explicitly accounted for several other pending federal standards. Table 64 and Table 65 provide lists of recent enacted or pending equipment standards, accounted for in this study's commercial and residential sectors for electric and gas end uses. Cadmus also incorporated other standards that, prior to 2015, have become effective for equipment:

- Commercial clothes washers (2013)
- Commercial boiler (2012)
- Commercial package terminal heat pumps (2012)
- Commercial refrigeration equipment (2012)
- Cooking ovens and ranges (2012)
- Dehumidifiers (2012)
- Faucet aerators (1994)
- Motors (2010)
- Pool heaters (2013)
- Residential central air conditioners and heat pumps (2015)
- Residential clothes dryers (2015)
- Residential dishwashers (2013)
- Residential refrigerators and freezers (2014)
- Room air conditioners (2014)
- Showerheads (1994)
- Walk-in cooler and freezer (2009)

For measures where a future standard would have a higher efficiency than a current standard market practice baseline, the baseline was adjusted to the new federal standard.

Table 64. Current and Pending Electric Standards by End Use

Equipment Electric Type	Existing (Baseline) Standard	New Standard	Sectors Impacted	Study Effective Year
Appliances				
Clothes washer	Federal standard 2007	Federal standard 2015	Residential	2016[1]
Clothes washer	Federal standard 2007	Federal standard 2018	Residential	2018
Automatic Commercial Ice Makers	Federal standard 2010	Federal standard 2018	Nonresidential	2018
Vending Machines	Federal standard 2012	Federal standard 2019	Nonresidential	2020[1]
Cooking				
Microwave	Existing conditions (no federal standard)	Federal standard 2016	Residential	2016
HVAC				
Heat pump (air source)	Federal standard 2006	Federal standard 2015	Residential	2017[2]
Residential Furnace Fans	Existing conditions (no prior federal standard)	Federal standard 2019	Residential	2020[1]
PTAC	Federal standard 2012	Federal standard 2017	Nonresidential	2017
Small, Large, and Very Large Commercial Package Air Conditioners and Heat Pumps	Federal standard 2010	Federal standard 2018 2023	Nonresidential	2018-2023[1]
Lighting				
General Service Fluorescent Lamps	Federal standard 2012	Federal standard 2018	Nonresidential	2018
Lighting general service and specialty lamp (EISA backstop provision)	Existing conditions (no federal standard prior to EISA 2007)	Federal standard 2020	Nonresidential/ Residential	2020
Metal halide lamp fixtures	Federal standard 2009	Federal standard 2017	Nonresidential	2017
Water Heat				
Pre-Rinse Spray Valves	Federal standard 2006	Federal standard 2019	Nonresidential	2019
Water heater > 55 gallons	Federal standard 2004	Federal standard 2015	Nonresidential/ Residential	2016[1]
Water heater ≤ 55 gallons	Federal standard 2004	Federal standard 2015	Nonresidential/ Residential	2016[1]

[1]To estimate potential, Cadmus assumed standards taking effect mid-year would start January 1 of the following year.

[2]Due to the uncertainty created by litigation, DOE did not enforce this standard until July 1, 2016.

Table 65. Current and Pending Gas Standards by End Use

Equipment Gas Type	Existing (Baseline) Standard	New Standard	Sectors Impacted	Study Effective Year
Water Heat				
Pre-Rinse Spray Valves	Federal standard 2006	Federal standard 2019	Nonresidential	2019
Water Heater > 55 gallons	Federal standard 2004	Federal standard 2015	Nonresidential/ Residential	2016[1]
Water Heater ≤ 55 gallons	Federal standard 2004	Federal standard 2015	Nonresidential/ Residential	2016[1]
HVAC				
Boiler	Federal standard 2012	Federal standard 2021	Residential	2021[2]
Furnace	Federal standard 1992	Federal standard 2015	Residential	2016[2]
Furnace	Federal standard 1992	Federal standard 2015	Nonresidential	2016

[1]To estimate the potential, Cadmus assumed standards taking effect mid-year will start on January 1 of the following year.

[2]The Wisconsin residential UDC requires a minimum boiler and furnace efficiency of 90% AFUE which exceeds the boiler federal standard 2021 requirements of 84% AFUE and the furnace federal standard 2015 requirements of 80% AFUE. The Wisconsin residential UDC requirement of 90% AFUE was used in place of these federal standard at the start of the study.

Since the beginning of 2015, the U.S. Department of Energy has updated or issued more than 20 federal standards affecting the energy efficiency of appliances, equipment, and lighting. However, there is some uncertainty related to the adoption of these federal standards now that the current administration has indicated it may want to reduce existing regulations and limit new ones.

These actions include delaying the effective date for newly revised efficiency standards for ceiling fans and a notice to delay a final test procedure for walk-in coolers and freezers. In addition, an executive order has been signed that generally requires the repeal of two existing regulations before any single, new regulation can be adopted.[20] The new Congress has also proposed legislation that could rescind or delay updated standards. This legislation includes the "Regulations From the Executive in Need of Scrutiny Act of 2017," (REINS Act) and the "Midnight Rules Act of 2017" (H.R.-21). According to this proposed legislation, the current administration could delay or stop up to 15 federal efficiency standards from going into effect. The outcome of this will not be known until after the completion of this study.

[20] The White House. Office of the Press Secretary. "Presidential Executive Order on Reducing Regulation and Controlling Regulatory Costs." January 30, 2017. Available online: https://www.whitehouse.gov/the-press-office/2017/01/30/presidential-executive-order-reducing-regulation-and-controlling

Based upon stakeholder feedback and Cadmus judgment, Cadmus modeled the technical potential under the assumption that these federal standards will go into effect at their expected effective dates. Based on a strict interpretation of each standard, Cadmus assumed customers would replace affected equipment with more efficient alternatives, and these would meet minimum federal standards. In other words, Cadmus assumed complete compliance.

Naturally Occurring Conservation

Cadmus' baseline forecast included naturally occurring conservation, which refers to reductions in energy use occurring due to normal market forces (e.g., technological change and changes in energy prices), improved energy codes and standards, and market transformation efforts (discussed below under Market Transformation Potential). These impacts resulted in changed baseline sales, from which Cadmus could estimate technical and achievable technical potential.

This analysis accounted for naturally occurring conservation in three ways:

1. The potential associated with certain energy-efficient measures assumed a natural adoption rate, net of current saturation. For example, total potential savings associated with ENERGY STAR appliances account for current trends in customer adoption. As such, the baseline energy forecast reflected the total technical savings potential from ENERGY STAR appliances.
2. The assessment accounted for gradual increases in efficiency due to retirement of older equipment in existing buildings, followed by replacement with units meeting or exceeding minimum standards at the time of replacement.
3. The assessment accounted for pending improvements to equipment efficiency standards that will take effect during the planning horizon, as discussed above. The assessment did not, however, forecast changes to standards yet to be passed.

As part the study, Cadmus estimated naturally occurring savings presented within the scenario analysis in the Non-Programmatic Savings Estimates section of Appendix D.

Market Transformation Potential

Market transformation refers to market interventions that remove barriers to energy efficiency and encourage the adoption of energy efficiency as standard practice. These can include "involuntary" measures (e.g., adoption of codes and standards) or can include "voluntary" measures (e.g., upstream interventions [with retailers and/or manufacturers]) that encourage adoption of more efficient technologies. As the potential study assumptions already accounted for codes and standards potential, market transformation potential only included voluntary interventions. In conjunction with this study, Cadmus conducted a market transformation potential analysis for select measures using a diffusion theory model and presented in a separate report.

Estimating Technical Potential

Once Cadmus fully populated the measure database, it used measure-level inputs to estimate technical potential over the planning horizon. To begin this process, Cadmus estimated savings from all measures included in the analysis, then aggregated the results to the end use, market segment, and sector levels.

Cadmus characterized individual measure savings, first in terms of the percentage of end-use consumption. For each non-equipment measure, the study estimated absolute savings using the following equation:

$$SAVE_{ijm} = EUI_{ije} * PCTSAV_{ijem} * APP_{ijem}$$

Where:

$SAVE_{ijm}$	=	Annual energy savings for measure, *m*, for end use, *j*, in customer segment, *I*
EUI_{ije}	=	Calibrated annual end-use energy consumption for equipment, *e*, for end use, *j,* and customer segment, *I*
$PCTSAV_{ijem}$	=	The percentage savings of measure, *m,* relative to the base use for the equipment configuration, *ije*, accounting for interactions among measures (such as lighting and HVAC), calibrated to annual end-use energy consumption
APP_{ijem}	=	Measure applicability: a fraction representing combined technical feasibility, existing measure saturation, end-use interaction, and any adjustments used to account for competing measures

For example, for wall insulation that saved 10% of space heating consumption, the final percentage of the end-use saved would be 5%, assuming an overall applicability of 50%. This value represented the percentage of baseline consumption that the measure saved in an average home.

Capturing all applicable measures, however, would require examining many instances in which multiple measures affected a single end use. To avoid overestimating total savings, Cadmus assessed cumulative impacts and accounted for interactions among various measures—a treatment called “measure stacking.”

The primary method used to account for stacking effects establishes a rolling, reduced baseline, applied sequentially upon assessment of measures in the stack. The following equations illustrate this technique, applying measures 1, 2, and 3 to the same end use:

$$SAVE_{ij1} = EUI_{ije} * PCTSAV_{ije1} * APP_{ije1}$$

$$SAVE_{ij2} = (EUI_{ije} - SAVE_{ij1}) * PCTSAV_{ije2} * APP_{ije2}$$

$$SAVE_{ij3} = (EUI_{ije} - SAVE_{ij1} - SAVE_{ij2}) * PCTSAV_{ije3} * APP_{ije3}$$

After iterating all measures in a bundle, the final percentage of the reduced end-use consumption provided the sum of each individual measure’s stacked savings, which Cadmus divided by the original baseline consumption. The order of the stacked, retrofit measures in a bundle is ranked from the highest to lowest saving measures, in terms of the percentage energy savings for that end use.

About Net-To-Gross

Cadmus' baseline forecast includes naturally occurring efficiency; that is, the forecast assumes that some customers would install efficiency measures even without an intervention from Focus on Energy. Cadmus adopted this assumption when calibrating baseline load forecasts to Focus on Energy participating utilities' forecasts. These sales histories (from which the utilities derive their forecasts) exhibited some level of naturally occurring savings. Failure to account for such savings in Cadmus' forecasts would have led to baseline forecasts that exceeded Focus on Energy participating utilities' forecasts or overestimated energy efficiency potential.

Cadmus' estimates of achievable energy efficiency potential did not consider the impacts on future program savings attribution by estimating or forecasting net-to-gross ratios, making explicit out-of-model adjustments for net-to-gross, or otherwise considering the possible effects of freeridership or spillover. As this study estimated achievable—not program—potential, program planners should consider the possible impacts to net savings when determining the program budgets and targets during the next quad planning process. Program planners should consider the following indicators for measures for which lower net-to-gross ratios are possible:

- Measures with low or no incremental cost
- Measures with low percentage incomplete values
- Measures with fast ramp rates
- Measures whose efficiency level distributions are relatively high

Economic Potential

Economic potential represents a subset of technical potential, consisting only of measures meeting cost-effectiveness criteria, based on to Focus on Energy participating utilities' avoided supply costs for delivering electricity. Cadmus used the MTRC to identify cost-effective measures in a manner consistent with Focus on Energy's program evaluation. Table 66 summarizes benefits and costs considered in calculating MTRC B/C ratios to develop the economic potential that served as the basis of the BAU achievable potential. Appendix D. Scenario Analysis provides additional economic and achievable potential scenarios that considered alternate cost tests, additional variables, and varying discount rate and carbon value assumptions.

Table 66. Summary of Costs and Benefit Components

Type	Component
Costs	Incremental measure costs (equipment and labor)
	Program administration and delivery costs
Benefits	Avoided energy costs (including secondary energy benefits)
	Avoided emissions benefits

Details follow of components shown in Table 66.

- **Incremental measure cost:** This study considered equipment and labor costs required to purchase a measure and sustain savings over each measure's EUL.
- **Program administration and delivery costs:** Cadmus assumed these costs were equal to 20% of incremental costs, informed by Focus on Energy's historical delivery and administration charges.
- **Avoided energy costs:** Avoided energy and deferred generation capacity benefits are costs that include the indirect energy savings achieved through reduced water consumption from measures such as low-flow showerheads. In addition, secondary energy benefits were considered for measures that saved energy on secondary fuels. Cadmus's end-use approach to estimating technical potential necessitated this treatment. For example, consider the cost of R-60 ceiling insulation for a home with a gas furnace and an electric cooling system. For the gas furnace end use, Cadmus classified energy savings that R-60 insulation produced for electric cooling systems, conditioned on the presence of a gas furnace, as a secondary benefit.
- **Reduced emissions** reflect the economic value of avoided greenhouse gas emissions, including carbon dioxide, nitrous oxides, and sulfur oxides.

In addition to each benefit and cost detailed above, Focus on Energy provided standard line loss factors and discount rates for this study.

Economic potential can exceed technical potential when a second measure, interacting with a given measure fails a B/C screen. For instance, suppose a homeowner installs an efficient air conditioner that reduces baseline cooling consumption from 1,000 kWh to 900 kWh. The homeowner then installs a weatherization measure that saves 10% off the baseline cooling consumption.

Consequently, the technical potential for this weatherization measure would equal 90 kWh (900*10%). If the efficient air conditioner measure did not prove cost-effective, the homeowner's baseline consumption would remain at 1,000 kWh. If the weatherization measure did prove cost-effective, the 10% savings would yield economic potential equal to 100 kWh (1,000*10%). In this case, economic potential for the weatherization measure would exceed the technical potential.

Avoided Energy Costs

Cadmus employed the same electric and natural gas avoided energy cost forecasts used by Focus on Energy to evaluate program and measure cost-effectiveness. In addition, the study included the same value of deferred generation capacity (i.e., $130.26 per kW-year) as Focus on Energy programs. Figure 32 and Figure 33 provide the avoided energy cost forecasts for electricity and natural gas, respectively. The forecasts continue through 2040, at which point the avoided natural gas forecast stays constant over the forecast period. The avoided electric energy cost forecast stays constant beginning in 2028.

Figure 32. Avoided Electric Energy Cost Forecast

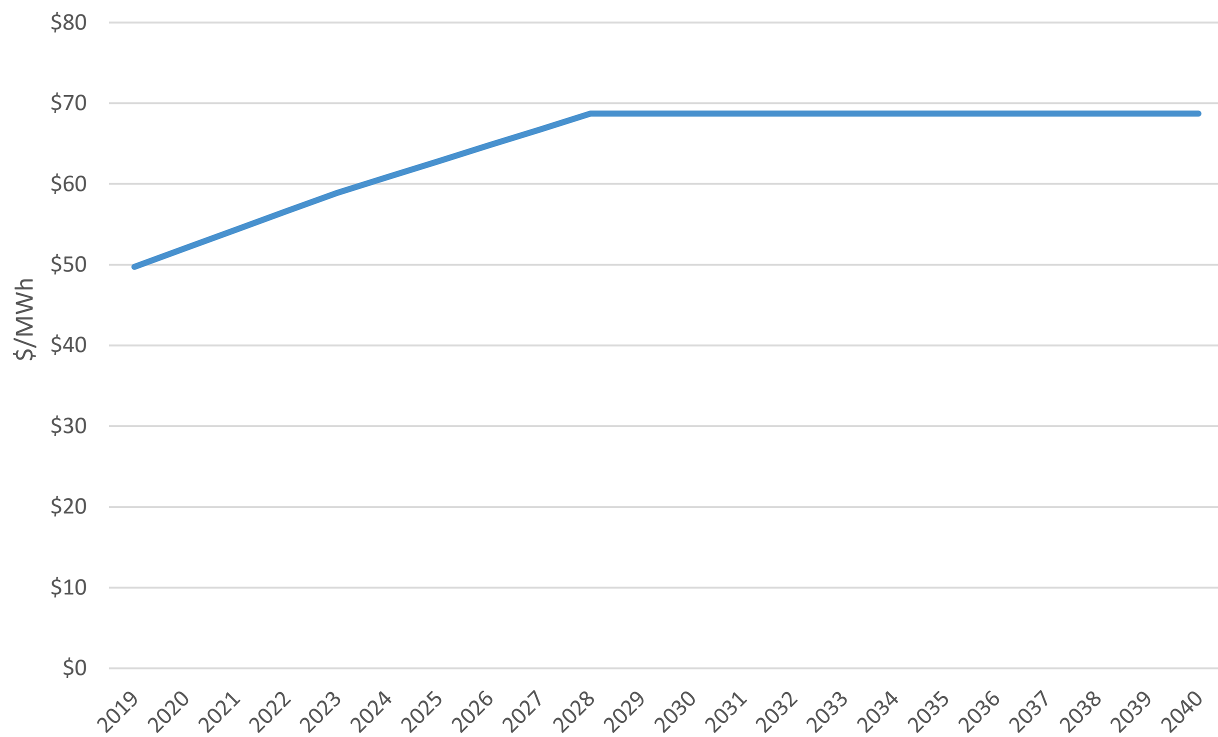
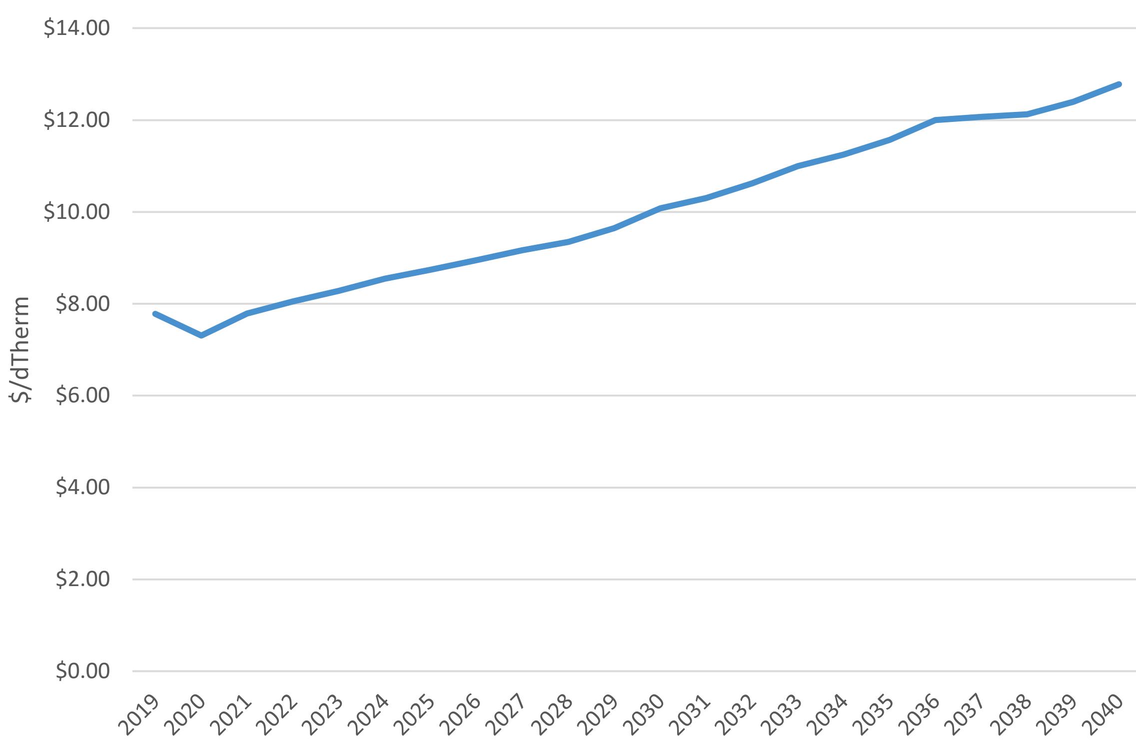


Figure 33. Avoided Natural Gas Energy Cost Forecast



Primary Data Collection

A large part of this project included conducting a comprehensive primary data collection effort, which included the four activities defined below:

- **Site visit:** A site assessment to collect comprehensive information on building characteristics, energy-consuming end uses (e.g., HVAC equipment, lighting inventory, server room closets), and equipment efficiencies. Site visits provide the highest level of detail to inform the study.
- **Detailed survey (full survey):** A phone survey to collect information on building characteristics, demographics, general information on energy-consuming end uses (e.g., fuel type, equipment type, estimate equipment age). In addition, information was collected on the customers' attitudes towards energy efficiency and willingness to adopt efficiency measures.
- **Short survey (willingness to pay):** A phone survey only regarding general building characteristics, demographics, and customers' attitudes towards energy efficiency and willingness to adopt efficiency measures. The building segments addressed with short surveys had detailed equipment data collected as part of the site visits.
- **Expert interview:** A phone interview of industrial subject matter experts (specifically, industry experts) to assess general baseline data. These industry experts' backgrounds included pulp and paper, ethanol, metal manufacturing, general process manufacturing, food manufacturing, and refrigeration.

Cadmus defined the stratified sampling plan for the surveys and site visits after receiving feedback from the technical advisory committee members. The allocated budget for this study could not support conducting site visits for all segments, therefore study priorities were identified. Site visit study priorities focused on building types that account for the majority of consumption in each respective sector representing high-impact and high value segments (e.g., single-family, offices, schools, retail, dairy farms, and industrial facilities). In addition, the study focused on segments with limited existing data and/or areas of interest that best overlap to existing Wisconsin Focus on Energy programs (e.g., multifamily and restaurants).

For the segments where site visits were conducted, a short survey collected limited building details and focused on the willingness to adopt efficiency measures battery of questions. Dairy farms were the exception; both site visits and detailed surveys were conducted in part because stakeholder feedback indicated difficultly recruiting dairy farms for site visits. For the segments without corresponding site visits, detailed surveys were conducted (e.g., health care, lodging, grocery, warehouse, commercial miscellaneous, and non-dairy agricultural).

Gathering data through site visits and detail surveys within the industrial sector can be challenging, especially at very large industrial facilities. These large facilities have unique site-specific characteristics that make conducting successful and meaningful site visits or surveys difficult. As a result, Cadmus interviewed industry experts (subject matter experts) to focus on these large industrial energy users.

Relying on subject matter experts with historical and institutional knowledge of Wisconsin industrial sites provided a broader perspective than conducting a few dozen site visits across all industries.

Overview of Sampling Methodology

Cadmus used stratified random sampling within each sector and information available from current utility tracking data to determine an appropriate stratification scheme. Table 67 shows this study's segment strata for the primary data collection site visits, including targets and achieved samples. In most strata, this study achieved or nearly achieved the target sample, except for agricultural dairy farms, where owners had difficulty committing to site visits due to their busy schedules. The overall sample frame for agricultural dairy farms also was relatively small compared to other segments; hence, the small response rates for site visits had a more pronounced effect.

Table 67. Data Collection Site Visit Size Sample Targets

Segment/Strata	Target	Achieved
Single-Family	106	103
Multifamily	70	88 Sites/92 Units
School	70	70
Office	70	70
Restaurant	70	70
Retail	70	70
Industrial	45	42
Agriculture Dairy	45	30
Total	**546**	**543**

In addition to site visits, Cadmus conducted 1,031 surveys across all sections, as shown in Table 68.

Table 68. Data Collection Phone Survey Size Sample Targets

<table>
<tr><th>Sector</th><th>Segment/Strata</th><th>Survey Type</th><th>Target</th><th>Achieved</th></tr>
<tr><td rowspan="2">Residential</td><td>Single-Family and Manufactured</td><td>Willingness to Pay</td><td>100</td><td>100</td></tr>
<tr><td>Multifamily</td><td>Willingness to Pay</td><td>70</td><td>70</td></tr>
<tr><td rowspan="9">Commercial and School/Government</td><td>School K-12/Universities</td><td>Willingness to Pay</td><td>70</td><td>70</td></tr>
<tr><td>Commercial and Government Offices</td><td>Willingness to Pay</td><td>70</td><td>70</td></tr>
<tr><td>Restaurant</td><td>Willingness to Pay</td><td>70</td><td>71</td></tr>
<tr><td>Retail</td><td>Willingness to Pay</td><td>70</td><td>74</td></tr>
<tr><td>Health Care (Hospitals/Out Patient)</td><td>Detailed Survey</td><td>70</td><td>70</td></tr>
<tr><td>Lodging</td><td>Detailed Survey</td><td>70</td><td>70</td></tr>
<tr><td>Grocery</td><td>Detailed Survey</td><td>70</td><td>70</td></tr>
<tr><td>Warehouse</td><td>Detailed Survey</td><td>70</td><td>70</td></tr>
<tr><td>Commercial Miscellaneous</td><td>Detailed Survey</td><td>70</td><td>70</td></tr>
</table>

Sector	Segment/Strata	Survey Type	Target	Achieved
Industrial	Large Industrial (>1 MW)	Expert Interview	10	16
	Small Industrial (<1 MW)	Willingness to Pay	70	70
Agricultural	Agriculture Dairy	Detailed Survey	70	69
	Agriculture Non-Dairy	Detailed Survey	70	71
Total			**1,020**	**1,031**

Cadmus determined the sample size for each stratum using the following equation:

$$n_0 = \left(\frac{z}{e} \times \mathrm{CV}\right)^2$$

Where n_0 represents the target sample size, z is the z-statistic determined by the desired level of confidence (e.g., for 90% confidence, z=1.645), e is the desired level of precision (e.g., e=10%), and CV represents the coefficient of variation—the ratio of an estimate's standard deviation to its mean. Sample sizes within each stratum were designed to achieve a target level of 10% precision with 90% confidence.

For the single-family and manufactured homes segment, Cadmus used an *a priori* CV=0.6, determined based on a recent study for Northwest Energy Efficiency Alliance's 2011–2012 Residential Building Stock Assessment.[21] For the multifamily segment and all segments within the commercial, government, industrial, and agricultural, Cadmus assumed the standard deviation would be about half the size of the mean, resulting in a conservative estimate of CV=0.5.

In general, Cadmus used simple random sampling within each stratum. For the industrial sector and some segments within the commercial and government sectors (e.g., schools/universities, offices, restaurants, and retail) Cadmus distributed sample points between large and small energy users using an optimal (Neyman) allocation scheme. Small and large energy use was determined individually for each sector/segment either by examining the distribution of facility energy use or by utility definitions of small and large.

Residential Surveys

Cadmus completed a phone survey of 170 residential customers (100 single-family and manufactured homes and 70 multifamily homes). Cadmus collaborated with a survey firm, St. Norbert's Research Institute, to engage the public regarding the following energy efficiency potential study topics:[22]

- Efficient product awareness and perceptions
- Customers' willingness to adopt and pay for energy efficiency measures

---

21 Northwest Energy Efficiency Alliance. "Regional Data Resources." Available online: http://neea.org/resource-center/regional-data-resources

22 Sample sizes for individual survey questions vary due to nonresponses.

- Demographic information and housing characteristics

To create a list of residential survey customers, Cadmus developed a stratified sample by key market segment. Sample sizes within each residential segment were designed to achieve 10% precision at 90% confidence for each residential segment. In addition, the surveys included a battery of questions to recruit customers for multifamily site visits.

Residential Site Visits

Cadmus visited 191 residential homes (103 single-family homes and 88 multifamily buildings) from summer 2016 to early 2017. The residential site visits primarily sought to provide detailed data on building shell, lighting, and equipment saturations. As part of Focus on Energy's program evaluation, Cadmus relied on the Residential Longitudinal Lighting Study to collect other non-lighting data (e.g., such as mechanical equipment, appliances, building shell, electronics, and other equipment). Similar to the residential phone survey, Cadmus developed a stratified sample based on the residential segment. In total, Cadmus randomly sampled 103 single-family and 17 multifamily homes all leveraged the Residential Longitudinal Lighting Study. Collecting the multifamily segment data can be difficult to gather for this segment using phone surveys; tenants often do not know building and mechanical characteristics. Therefore, additional multifamily site visits were conducted, separate from the Residential Longitudinal Lighting Study, to achieve the sample targets. Supporting the data collection efforts, Cadmus collaborated with SeventhWave, which conducted the 71 multifamily site visits. In total, 88 multifamily sites with 92 in-unit apartments were visited.

Data collection produced the following major findings:

- An average single-family home had 2.56 residents, with an average home square footage of 1,652.
- 95% of single-family homes and 84% of multifamily homes had some mechanical cooling, either with central cooling or window air conditioners.
- 86% of single-family homes with natural gas furnaces bettered Wisconsin's Uniform Dwelling Code of 90% AFUE, with an overall average of 91.5% AFUE.
- The average single-family home had roughly 2.8 televisions and 1.3 computers,[23] with 2.7 power strips. The average multifamily home had 1.1 televisions and 0.9 computers.
- Single-family homes had lighting saturations of 10% LEDs, 31% CFLs, 48% incandescents/ halogens, and 9% linear fluorescents.

[23] These include desktops and laptops. The number of laptops, however, may be underrepresented if the laptop was not in the home during the site visit.

Commercial and Government Phone Surveys

Cadmus, St. Norbert's Research Institute, and Martec Group conducted 635 phone surveys of commercial and government entities to provide information for assessment of Focus on Energy's energy efficiency potential. The commercial and government survey questions covered the following topics:

- Saturation of energy-consuming equipment and efficient technologies
- Equipment fuel shares and building envelope characteristics
- Efficient product awareness and perceptions
- Customers' willingness to adopt energy efficiency measures
- Firmographic and building characteristic information

To create a list of survey customers, Cadmus developed a stratified sample, spanning Focus on Energy participating utilities' largest commercial and government segments (by sales). The sample sought to achieve 10% precision at 90% confidence for each segment. The phone surveys also served as a tool to recruit interested customers to participate in site visits.

Commercial and Government Site Visits

Cadmus visited 280 commercial and government sites (customers were recruited through phone surveys) from summer 2016 to early 2017. Cadmus developed a stratified sample, based on Focus on Energy participant utilities' largest commercial and government segments by energy sales, which generally accounted for a significant portion of the energy efficiency potential in the commercial and government sector. Cadmus also gathered input from stakeholders and industry experts to ensure that the study focused on the highest priority segments in Wisconsin. From these sources, Cadmus determined that the schools, offices, restaurants, and retail establishment segments had large overall populations, energy sales, and interest that would benefit from more granular data collection.

The site visits primarily sought to provide additional validation for the phone surveys and to collect detailed data on system and equipment saturations. Major data collection findings included the following:

- 53% of commercial and government buildings were built before 1970.
- 77% of small retail buildings did not meet the 2018 federal cooling standard (11.6 to 12.9 IEER).
- 59% of boilers (less than 300 kBtuh) met or were less than the 2013 federal standard of 82% AFUE. More than three-quarter of boilers (greater than 300 kBtuh) exceeded current 2012 federal standards for thermal efficiency of 75%.
- The commercial and government sectors had low saturations of linear fluorescent T12s, ranging from 7% to 30% (across the sectors).[24]
- The saturation of linear LEDs ranged from 0.2% to 10%, depending on the building segment.

[24] These percentages represent the linear fluorescent saturation by wattage.

Industrial Phone Surveys and Site Visits

Cadmus, St. Norbert's Research Institute, and Martec Group conducted 70 phone surveys of industrial companies to provide information for the assessment of Focus on Energy's energy efficiency potential. The industrial survey questions covered the following topics:

- Energy management practices
- Customers' willingness to adopt energy efficiency measures
- Firmographic and building characteristic information

To create a list of survey customers, Cadmus developed a sample of Focus on Energy participating utilities' industrial customers. With a sample designed to achieve 10% precision at 90% confidence, Cadmus achieved its sample target of 70 completed surveys.

Cadmus also conducted 16 in-depth phone interviews with industry experts from industries as disparate as paper manufacturing and waste water treatment. These interviews sought to assess current large industrial facilities' standard practices regarding energy efficiency, energy management, and process loads. Details from the industrial expert interviews have been summarized in Appendix G.

Cadmus also visited 42 industrial sites from summer 2016 to early 2017, with a sample target of 45 sites. The major data collection findings included the following:

- Experts said 41% of facilities had an active preventative maintenance program, and 25% of facilities employed an energy manager.
- Regarding lighting wattage saturations, 91% of linear fluorescents were T8s, with only 4% representing T12s.
- Site visits and expert interviews indicated that upgrading measures related to compressed air systems are still a viable option for energy savings (i.e., the relatively easy process of upgrading air compressor systems remains an opportunity).

Agricultural Phone Surveys and Site Visits

Cadmus, St. Norbert's Research Institute, and Martec Group conducted 140 phone surveys of agricultural companies to provide information for assessment of Focus on Energy's energy efficiency potential. The agricultural survey questions covered the following topics:

- Saturation of energy-consuming equipment and efficient technologies
- Equipment fuel shares and building envelope characteristics
- Customers' willingness to adopt energy efficiency measures
- Firmographic and building characteristic information

To create a list of survey customers, Cadmus developed a sample of Focus on Energy participating utilities' agricultural customers, stratified between dairy operations and non-dairy agricultural operations. The samples were designed to achieve 10% precision at 90% confidence.

Cadmus also visited 30 dairy operations from summer 2016 to early 2017, targeting 45 sites. The reason for fewer site visits was mainly because owners had difficulty committing to site visits because of their busy schedules. Cadmus was aware of this possibility (identified from stakeholder feedback) so also conducted a detailed survey to collect additional site information. Major findings from these data collection efforts (site visits and surveys) included the following:

- 50% of dairy farms had a scroll compressor, with 53% of farms participating in refrigeration tune-ups annually.
- Dairy farms with vacuum pumps and milk pumps used variable speed controls 62% and 57% of time, respectively.
- 61% of dairy farms had some type of refrigeration heat recovery system, with 70% using plate heat-exchanger milk pre-coolers.
- By lighting wattage saturations, dairy farms had 26% socket-type lighting fixtures, 69% of which were incandescents or halogens; 35% were linear type lighting fixtures, with 15% T12s. High intensity discharge type fixtures represented 39% of the overall wattage, with 31% either high-pressure sodium or mercury vapor units.
- Site visits and surveys indicated available technical potential through installing variable frequency drives on fans and pumps.

The survey instruments used in this study, for all sectors described above, can be found in Appendix F.

Other Focus on Energy-Specific Data

In addition to phone surveys and site visits, Cadmus received various data from stakeholders and evaluation-related data; these included the following:

- Focus on Energy's energy best practices guidebooks, covering various industrial segments (e.g., pulp and paper, waste water treatment, metal casting)
- Focus on Energy's SPECTRUM database
- Focus on Energy's 2017 draft TRM work papers
- Stakeholder data, consisting of industrial project tracking data
- Residential HVAC Wisconsin region sales data
- Residential lighting Wisconsin region sales data